Proposed Water Quality Objectives
through Manitoba's Watershed Classification Process:

Red and Assiniboine Rivers and their Tributaries within and downstream of the City of Winnipeg

Technical Document

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July, 1991

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TABLE OF CONTENTS

PAGE

LIST OF TABLES ..... i-ii
LIST OF FIGURES ..... iii-iv

1.0 INTRODUCTION 1
1.1 MANITOBA SURFACE WATER QUALITY OBJECTIVES 1
1.2 THE WATERSHED CLASSIFICATION PROCESS 3
2.0 CLASSIFICATION AREA 8
3.0 WATERSHED DESCRIPTION 11
3.1 CLIMATE 11
3.2 DEMOGRAPHICS 12
3.3 GENERAL ECONOMIC BASE 12
3.4 HYDROLOGY 12
3.5 GEOLOGY 19
3.6 SOILS 19
4.0 WATER USES 20
4.1 DOMESTIC CONSUMPTION 23
4.2 AQUATIC LIFE AND WILDLIFE 24
4.2.1. FISHERIES 24
4.2.1.1. RED AND ASSINIBOINE RIVER FISHERIES 24
4.2.1.2. TRIBUTARY FISHERIES 25
4.2.2. OTHER AQUATIC LIFE AND WILDLIFE 29
4.2.2.1. RED AND ASSINIBOINE RIVERS 29
4.2.2.2. TRIBUTARIES 29

4.3 INDUSTRIAL 30
4.4 IRRIGATION 30
4.4.1. AGRICULTURAL IRRIGATION 30
4.4.2 PARK AND GOLF COURSE IRRIGATION 31
4.5 RECREATION 34
4.5.1. PRIMARY RECREATION ACTIVITIES 34
4.5.2. SECONDARY RECREATION ACTIVITIES 35
4.5.2.1. SPORT FISHING 35
4.5.2.2. BOATING 37
4.5.2.3. SPECIAL EVENTS 38
4.5.2.4. RIVERBANK PARKS 38
4.5.2.5. CAMPING AND PICNICKING 39
4.5.2.6. HUNTING 39
4.5.3 CALCULATION OF IMMERSION EVENTS FROM PRIMARY AND SECONDARY RECREATION ACTIVITIES 40
4.5.4. OTHER RIVERBANK RECREATION ACTIVITIES 40
4.5.4.1. HISTORIC SITES 40
4.5.4.2. GOLF AND COUNTRY CLUBS 41
4.6 DOMESTIC WASTEWATER DISCHARGE 41
4.7 INDUSTRIAL WASTEWATER DISCHARGE 45
4.8 OTHER RIVER USES 45
5.0 PROPOSED CLASSIFICATION 47
6.0 WATER QUALITY 51
6.1 RED AND ASSINIBOINE RIVERS WATER QUALITY 51
6.1.1 BACTERIOLOGICAL PARAMETERS: FECAL COLIFORM 51
6.1.2 PHYSICAL PARAMETERS 54

6.1.3 NUTRIENTS 61
6.1.3.1. NITROGEN 61
6.1.3.2. PHOSPHORUS 67
6.1.4 INORGANICS AND METALS 71
6.1.4.1. INORGANICS 71
6.1.4.2. METALS 76
6.1.5 PESTICIDES AND OTHER ORGANICS 78
6.1.5.1. ORGANICS 79
6.1.5.2 PESTICIDES 79
6.2 TRIBUTARIES WATER QUALITY 81
6.2.1 BACTERIOLOGICAL PARAMETERS 81
6.2.2 PHYSICAL PARAMETERS 82
6.2.3 NUTRIENTS 82
6.2.4 INORGANICS 83
6.2.5 ORGANICS 84
6.3 WATER QUALITY SUMMARY 84
6.3.1. MICROBIOLOGICAL QUALITY 84
6.3.2. UN-IONIZED AMMONIA TOXICITY 85
6.3.3. NUTRIENT LOADING 85
6.3.4. OXYGEN 86
6.3.5. PESTICIDES 86
7.0 SUMMARY AND MORE INFORMATION 87
8.0 LITERATURE CITED 89

APPENDIX A: WATER QUALITY DATA ..... (separate document)

LIST OF TABLES

NUMBER	DESCRIPTION	PAGE
TABLE 1	Monthly average (1951-1980) temperature (^{o}C) data for the Winnipeg area.	11
TABLE 2	Monthly average (1951-1980) precipitation data for the Winnipeg area.	11
TABLE 3	Population estimates for major cities and municipalities within the classification area.	12
TABLE 4	Drainage area and monthly average flow rates for the tributaries of the Red and Assiniboine rivers within the study area.	17
TABLE 5	Water right licences issued by the Water Resources Branch of Manitoba Natural Resources.	20
TABLE 6	Typical 1989 water consumption values (m^3) for the town of Selkirk.	24
TABLE 7	Summary of Red River water intake for domestic consumption between 1985-1991.	24
TABLE 8	Species list of fish found upstream and downstream of Lockport in the Red River.	26
TABLE 9	Industrial consumption of surface water in the classification area.	30
TABLE 10	Greenhouse, fruit and vegetable irrigation use within the classification area.	31
TABLE 11	River use for the irrigation of City of Winnipeg public golf courses.	32
TABLE 12	River use for the irrigation of private public golf courses.	32
TABLE 13	City of Winnipeg community and regional parks, and cemetery grounds estimated river water usage.	33
TABLE 14	Results of a creel census conducted on the Red River between Lockport and Netley Creek from May 15 to October 30, 1982.	36

TABLE 15	Recreational fishing use numbers for the Red River between Lockport and Lake Winnipeg for the open water season, based on 1988/1989 creel survey conducted by the Fisheries Branch of Manitoba Natural Resources.	37
TABLE 16	Riverbank parks located adjacent to waterways within the classification area.	39
TABLE 17	Estimated immersion (body contact) events in the Red and Assiniboine rivers between April and October of 1990.	41
TABLE 18	Golf and country clubs located adjacent to rivers within the classification area.	41
TABLE 19	Domestic wastewater dischargers within the Assiniboine River.	42
TABLE 20	Domestic wastewater dischargers within the Red River.	43
TABLE 21	Domestic wastewater dischargers within the tributaries.	44
TABLE 22	Industrial discharge within the classification area.	46
TABLE 23	Proposed classification of surface waters.	48
TABLE 24	Description of data base used for water quality assessment.	52
TABLE 25	Sodium adsorption ratio as it relates to the suitability of water for irrigation use	75
TABLE 26	Summary statistics for total organic carbon concentrations in the Red and Assiniboine rivers (1980-1989).	79

LIST OF FIGURES

NUMBER	DESCRIPTION	PAGE
FIGURE 1	Process of watershed classification.	4
FIGURE 2	Surface waters within the classification area.	9
FIGURE 3	Manitoba's watershed basins.	13
FIGURE 4	Compositional origin of flows in the Red and Assiniboine rivers near the City of Winnipeg.	14
FIGURE 5:	Average daily flow rates at three stations on the Red and Assiniboine rivers.	16
FIGURE 6	Exceedence of the proposed fecal coliform objectives for the Red River, upstream and downstream of Winnipeg (1980-89).	55
FIGURE 7	Exceedence of the proposed fecal coliform objectives for the Assiniboine River, upstream and downstream of Winnipeg (1980-89).	56
FIGURE 8	Fecal coliform concentrations upstream and downstream of Winnipeg.	57
FIGURE 9	Monthly average turbidity levels at sampling locations along the Red River (1980-89).	59
FIGURE 10	Monthly average un-ionized ammonia exceedences at sampling locations along the Assiniboine River (1980-89).	63
FIGURE 11	Monthly average un-ionized ammonia exceedences at sampling locations along the Red River (1980-89).	64
FIGURE 12	Monthly average ammonia concentrations at sampling locations along the Red River.	65
FIGURE 13	Monthly average total Kjeldhal nitrogen concentrations at sampling locations on the Red River.	66

FIGURE 14 Monthly average nitrate/nitrite concentrations at sampling locations on the Red River. 68

FIGURE 15 Monthly average phosphorus concentrations at sampling locations on the Red River. 70

1.0 INTRODUCTION

The Honourable Glen Cummings, Minister of Manitoba Environment, has asked the Clean Environment Commission to hold public hearings in the fall of 1991 to define a vision for the Red and Assiniboine rivers and their tributaries within and downstream of the City of Winnipeg. These Watershed Classification hearings will establish Water Quality Objectives for these rivers and streams.

The Red and Assiniboine rivers, within the classification area, are currently receiving discharges from the City of Winnipeg's three sewage treatment plants, 41 combined sewer overflows, and 75 major land drainage outfalls. In addition, municipal and non-municipal wastewater treatment facilities, and industrial dischargers are contributing to the point source pollution load on these rivers and their tributaries.

The Clean Environment Commission has been requested to convene public hearings and provide a report and recommendations on proposed water quality objectives for the Red and Assiniboine rivers and their tributaries within a defined geographical area.

Once a classification is established for the area, a feasible long-term management strategy can be developed. Further hearings will be held to establish site-specific environmental licences for facilities, such as the City of Winnipeg's three sewage treatment plants. These licensing hearings will be guided by the overall water quality objectives established in the initial Watershed Classification hearings.

The 1991 fall hearings will focus on an area which includes the Red River from the South Floodway Control Structure to Lake Winnipeg, and the Assiniboine River from St. Francois Xavier (west of Winnipeg) to the Red River. Water Quality Objectives will also be established for the major tributaries of the Red and Assiniboine rivers within this geographic area. These include the Seine River, La Salle River, Cook's Creek, Bunn's Creek, Devils Creek, Sturgeon Creek, Omand's Creek and Netley Creek.

This proposal is prepared for presentation to the Clean Environment Commission as background information for the classification of the Red and Assiniboine rivers, and their tributaries within the designated area.

1.1 MANITOBA SURFACE WATER QUALITY OBJECTIVES

Manitoba Surface Water Quality Objectives define the quality of water which is necessary to protect important water uses. When met, these objectives protect human health, aquatic plant and animal communities, and other designated water uses. The Manitoba Watershed Classification process is an example of sustainable development at work, as we protect and manage our environment for the benefit of Manitobans today while ensuring that these important environmental assets will be available for future generations to also use and enjoy.

As an important step towards ensuring the sustained use of Manitoba's surface waters, the Manitoba Surface Water Quality Objectives were developed (3). These objectives contain principles, policies, narrative objectives and numerical objectives necessary to protect water resources in Manitoba. The objectives provide an essential link between regulatory statutes, water quality monitoring data, toxicological information, water uses and public expectations. The Manitoba Surface Water Quality Objectives are utilized in the development of long-term water management strategies in the province, such as the Watershed Classification system.

The Manitoba Surface Water Quality Objectives define minimum levels of quality necessary for the protection of important water uses in Manitoba. These objectives are in two principal forms, namely general or narrative surface water quality objectives, and specific or numeric surface water quality objectives.

Narrative surface water quality objectives are general statements that attempt to describe the conditions within Manitoba's aquatic systems that should be avoided. While such narratives statements are of less practical value than are specific numerical surface water quality objectives, the lack of scientific information precludes the development of more specific objectives at the present time. These narrative statements have been developed for colour, odor, taste, turbidity, floating materials, oil and grease, deposits on bottom sediments or shorelines, nutrients, toxic substances, litter, and flow.

Numerical surface water quality objectives have been adopted from other jurisdictions and in some cases have been site-adapted for use in Manitoba. Such objectives are included for over 80 variables. The numerical surface water quality objectives are arranged according to the important water uses within Manitoba.

The Manitoba Surface Water Quality Objectives are appropriate for most applications in the province. Modifications to the objectives can occur if, for example, lower or greater sensitivity of aquatic species has been demonstrated. The objectives are to be interpreted as maximum acceptable concentrations which are not to be exceeded at any time or in any place, except where otherwise specified (*i.e.* mixing zones, low flow conditions).

The objectives inherent in the classification are based on current scientific knowledge. The Manitoba Surface Water Quality Objectives were last reviewed during a public hearing process conducted by the Clean Environment Commission in 1984 (41).

The Manitoba Surface Water Quality Objectives are designed to protect the following uses:

- Class 1: Domestic consumption.
- Class 2: Aquatic life and wildlife.
  Category A: Cold water aquatic life, cool water aquatic life and wildlife.
  Category B: Cool water aquatic life and wildlife.
- Class 3: Industrial consumption.
- Class 4: Agricultural consumption.
  Category A: Greenhouse irrigation
  Category B: Field crop irrigation
  Category C: Field crop irrigation
  Category D: Livestock watering
- Class 5: Recreation.
  Category A: Primary recreation
  Category B: Secondary recreation
- Class 6: Other uses.

The specific numeric and narrative objectives are detailed in the Manitoba Environment 1988 document "Manitoba Surface Water Quality Objectives" (3). The Manitoba Surface Water Quality Objectives offers four different levels of protection as described below (2).

1.2 THE WATERSHED CLASSIFICATION PROCESS

The waters of Manitoba's rivers, lakes and streams are crucial to the well-being of our Province. To protect the quality of the surface waters and develop feasible long-term water quality management strategies, Manitoba has adopted a Watershed Classification Process.

Watershed classification identifies water uses and sets Manitoba Surface Water Quality Objectives to protect beneficial water uses. This is accomplished through a process that encourages wide-ranging public debate on the current and potential water uses. In doing so, the principles of sustainable development can be applied to these important environmental assets.

Manitoba's rivers, lakes and streams have a number of important uses including domestic and agricultural consumption, aquatic life and wildlife habitat, recreation and industrial use. Manitoba's Watershed Classification Process has been put in place primarily to maintain, protect or enhance these beneficial uses.

Based on the concept that consultation and public involvement is critical in developing a water quality management plan that benefits the whole community, the Watershed Classification Process moves beyond government to involve input and public participation from industries, environmental groups and private citizens.

A FOUR STEP PROCESS:

The Watershed Classification Process involves four important steps:

1. Technical evaluation of the watershed water quality, normally undertaken by Manitoba Environment.
2. Public review, often including public hearings conducted by the Clean Environment Commission, which provides recommendations to the Minister.
3. Classification of the watershed by the Minister.
4. Implementation of a long-term feasible water quality management strategy, according to the objectives set out in the Watershed Classification.

In some cases, further environmental reviews and hearings will be required on site-specific projects or facilities, such as sewage lagoons and industrial plants, which will have a significant impact on achieving the objectives established in the Watershed Classification. Figure 1 outlines the watershed classification process.

1. THE TECHNICAL EVALUATION

In this initial step, the Water Quality Management Section of Manitoba Environment prepares a report on the proposed watershed classification which involves the following:

- Existing and potential water uses for the water-bodies are identified within the classification area; for example, these may include drinking water, aquatic life and wildlife, recreation, agricultural use or industrial consumption.

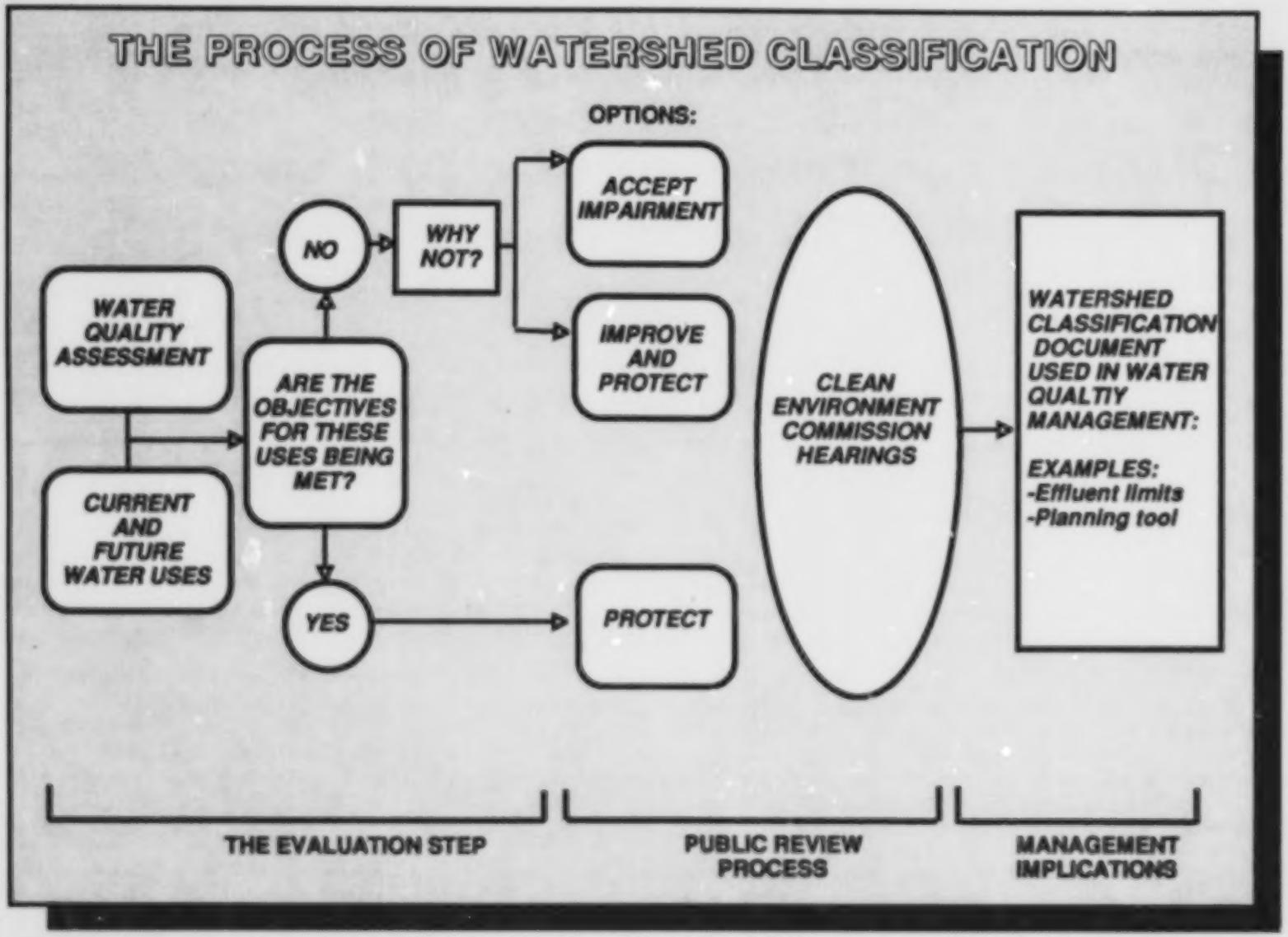


FIGURE 1: Process of watershed classification, whereby surface water quality objectives are applied to individual streams, lakes, or entire watersheds in order to protect multiple water uses.

- The existing water quality conditions are then evaluated. For each water use, Manitoba has adopted Surface Water Quality Objectives which define minimum levels of quality necessary to protect important water uses. Manitoba Surface Water Quality Objectives are used to assess the existing compatibility of the water quality conditions with the identified uses. This information is expressed as the percent of time that the water does not meet the objectives. When possible, the cause and trends of these water quality problems are also documented.

- For each water body within the classification area, water quality objectives and an appropriate level of protection are proposed. The Manitoba Surface Water Quality Objectives offers four different levels of protection for our waters. The four levels of protection are as follows:

Routine Protection

The routine level of protection applies to water bodies which may have been affected by development to some degree, for example, in the populated region in the southern portion of the province. This level of protection consists of the following combination:

- The use of economically available technology-based treatment systems to remove as many pollutants as practical; and

- The use of Manitoba Surface Water Quality Objectives to develop effluent discharge limitations for those remaining pollutants that may not be adequately removed by the standard treatment systems.

This level of protection prevents unacceptable impacts, while recognizing that some changes will result from the developed nature of the region.

High Quality Designation

This designation places greater restriction upon development within certain pristine areas in the province. A "high quality designation" may be considered for water-bodies which:

- flow through or are bounded by provincial parks;

- support diverse or unique animal or plant life that is sensitive to man-induced water quality alterations;

- are within relatively undisturbed watersheds;

- possess outstanding water quality characteristics; or

- are designated as Canadian Heritage Rivers.

Exceptional Value Designation

Bodies of water designated as exceptional value would be given the highest level of protection. Development would be prohibited in such areas, thus ensuring that water quality would not undergo man-induced changes from nearby development. Water bodies falling into this category may include:

- ecological reserves;

- wild and scenic rivers or lakes;

- waters that provide habitat for rare and endangered plants or animals;

- waters considered sensitive such that irreversible harm will result following human impact;
- waters whose exceptional quality and value as a future resource precludes the assignment of present uses; or
- waters designated as Canadian Heritage Rivers.

No Protection

Circumstances at some sites may determine that a specific water body should not be afforded protection, such as a small lake or pond that may become incorporated into the wastewater treatment system of an industrial or municipal development.

2. THE PUBLIC REVIEW

Prior to the Clean Environment Commission hearings, Manitoba Environment releases the proposed Watershed Classification report for wide ranging public, technical and scientific review. The documents, which describe the water uses and water quality conditions, also propose Water Quality Objectives for the classification area. They are presented so that people affected by the process have the information they may need to make decisions and represent their interests at the hearings.

The date and location of the hearings are advertised in local papers, and background documentation is made available in Manitoba Environment's public registries within the area being classified.

The public is encouraged to offer their comments or concerns regarding the proposed classification to the Clean Environment Commission hearings. These comments or concerns can be in a verbal or written format.

3. CLASSIFICATION BY THE MINISTER

The Clean Environment Commission evaluates the technical information and public opinions, and completes a detailed report which offers recommendations to the Minister of Manitoba Environment.

The Minister may accept or reject the recommendations, or request additional information from Manitoba Environment, the Clean Environment Commission, or others as deemed necessary. The Water Quality Management Section of Manitoba Environment, upon receipt of the Minister's recommendations, will then release a finalized watershed classification document.

4. WATER QUALITY MANAGEMENT PLAN

Once the Watershed Classification is finalized, it is used as the basis of managing water quality within the classification area. For example, it can be used:

- As a Planning Tool: Developers can use the Surface Water Quality Objectives assigned through the Watershed Classification process early in their planning to assist with decisions on the type and cost of environmental controls required at any proposed locations.
- To Develop Effluent Discharge Limits: Manitoba Environment uses the Water Quality Objectives set through the Watershed Classification process to assist with the development of legally-binding effluent discharge limits. While Watershed Classification provides overall objectives for the watershed, individual licences may be required by

communities, industries and individuals which may have an impact on achieving those objectives. For an example, a community discharging its sewage into a river requires a site-specific environmental licence, a process which may require another Clean Environment Commission hearing dealing with that particular project. For an example, after the Clean Environment Commission completes its Water Classification hearings for the Red and Assiniboine watershed currently under review, it will be asked to hold public hearings to establish site-specific licences for the City of Winnipeg's three sewage treatment plants

- To Assist with Controlling Pollution From Some Land-use Practices: The Surface Water Quality Objectives assigned through the Watershed Classification process, can be used to assist in controlling certain land-use practices that may release non-point source pollutants into nearby surface bodies of water.

BACKGROUND

In 1976, the Environmental Management Division of Manitoba Environment prepared a proposal outlining a system of Water Quality Objectives and watershed classifications, that would serve as the basis of a surface water quality management program for Manitoba. Since that time four watersheds have been classified.

- *The Souris River Watershed.*
  The first Clean Environment Commission Watershed Classification hearings dealt with the classification of the Souris River principal watershed division in 1979.
- *The Entire Red River Watershed.*
  Evidence presented at these hearings indicated that the water quality of the Red River through and downstream of the City of Winnipeg was not of sufficient quality to permit expected and desired uses. This 1981 report recommended a more detailed proposal be developed for individual portions of this watershed, such as the area within and downstream of the City of Winnipeg.
- *The Grass-Burntwood Principal Watershed Division.*
  The "Report on a Proposal for the Classification of Manitoba's Surface Water: Grass-Burntwood Rivers Principal Watershed Division" was published in 1981.
- *Clearwater Lake.*
  The Classification of Clearwater Lake Watershed Region was completed in 1989. The Clean Environment Commission supported the proposal of a "High Quality Designation" for this watershed.

2.0 CLASSIFICATION AREA

The area under consideration in this classification includes the Red River from the south floodway control structure to Lake Winnipeg, and the Assiniboine River from St. Francois Xavier (#1 Highway West) to the Red River. The major tributaries within this geographic area are also classified. These include the Seine River, La Salle River, Cook's Creek, Bunn's Creek, Devil's Creek, Sturgeon Creek, Omand's Creek and Netley Creek. Figure 2 illustrates the classification area and the location of these tributaries.

RED RIVER:

The Red River is approximately 128 km in length from St. Norbert, through the City of Winnipeg to its mouth at Lake Winnipeg. A significant portion of Manitoba's population lives within this portion of the Red River watershed. In addition to the City of Winnipeg and Selkirk, a number of smaller communities and extensive rural residential development exist within this area. Residential developments are interspersed amongst agricultural operations.

NETLEY MARSH:

The marsh lies approximately 65 miles north of Winnipeg. The delta, comprised of approximately 24,000 ha (60,000 acres) of marsh and 12,000 ha (30,000 acres) of agricultural land, lies at the southern-most end of Lake Winnipeg (8). Agricultural land in this area above 718 feet in elevation is used for cereal crop, summer fallow or forage crop production. Below this elevation, much of the vegetation is comprised of wetland species, and is not used extensively for agricultural production. The towns in this area include Libau and Scanterbury to the east, and Clandeboye, Netley and Petersfield to the west.

ASSINIBOINE RIVER:

Land adjacent to the Assiniboine River within the classification area is both agricultural and residential. Extensive riverbank development exists on the Assiniboine in both Winnipeg and Headingley.

OMAND'S CREEK:

Although the creek has been significantly modified, this waterway still supports a diverse aquatic and semi-aquatic community. Omand's Creek originates outside the west perimeter highway, and winds its way through Winnipeg to the Assiniboine River near Polo Park. There have been recent initiatives to preserve and protect portions of this creek from future encroachment.

STURGEON CREEK:

Sturgeon Creek serves as a drainage outlet for a large agricultural area and for the urban development in the St. James-Assiniboia area. Portions of the creek have also been landscaped and maintained as park area for recreational use. The creek was the site of Cuthbert Grant's Mill in the last century and the lands surrounding the junction of Sturgeon Creek with the Assiniboine River are known to be Aboriginal burial grounds (9). Storm water drainage peaks have caused erosion problems, which has created conflict between its use as a stormwater drain as well as park space.

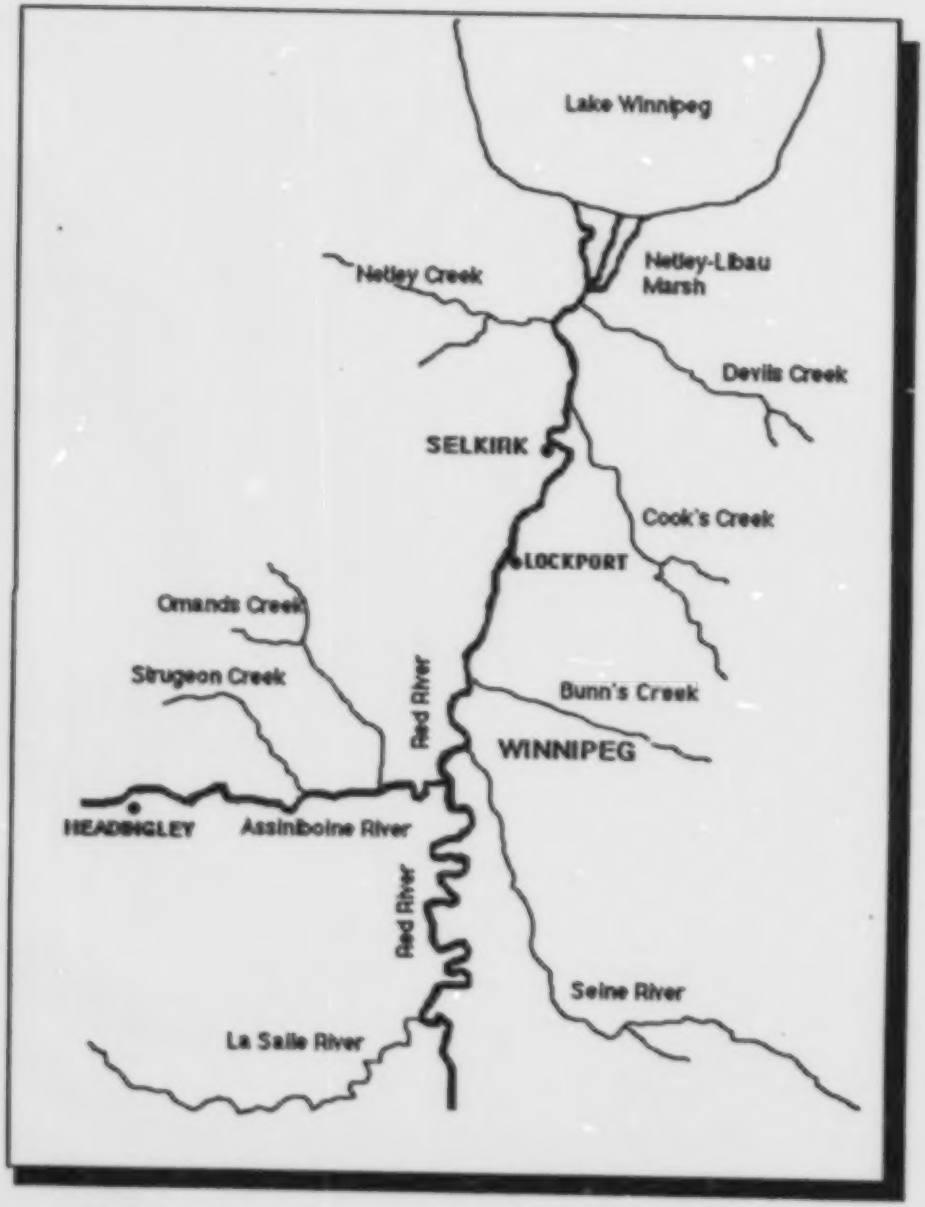


FIGURE 2: Surface waters within the classification area.

BUNN'S CREEK:

Despite passing through dense residential area in the East Kildonan area of Winnipeg, Bunn's Creek has remained relatively unaltered between the Red River and Lagimodiere Boulevard. East of Lagimodiere, the watercourse changes to a straight drain, referred to as Cordite Ditch. A portion of the creek has been developed into a residential park.

LA SALLE RIVER:

The La Salle River passes through the towns of Elie, Starbuck, La Salle and discharges into the Red River near St. Norbert. The hydrology of the river is affected by numerous dams located along the length of the river. As a result of limited encroachment, much of the floodplain of the river remains in its natural state (9). A large tract of land has been preserved in La Barriere Park.

SEINE RIVER:

The Seine River originates in the marshy and wooded area west of the Bedford Ridge, approximately 80 km southeast of Winnipeg. The Seine River passes by the towns of Ste. Anne and Lorette, before winding its way through Winnipeg to the Red River south of the Louise Bridge in downtown Winnipeg.

Outside of the City of Winnipeg, the Seine River watershed supports economic activities such as mixed farming, intensive livestock and dairy production, forage cropping, aggregate extraction, peat soil removal and residential development.

Within the City of Winnipeg, extensive encroachment of the Seine River has resulted in increased pollution loading. Recent environmental concerns have been identified with respect to the river being used as a dumping ground for construction material and residential garbage. Low flow conditions in the river have exacerbated the water quality problems along its reach.

NETLEY CREEK:

Netley Creek enters the Red River just south of Netley Marsh. Netley Creeks and its tributaries (Wavey and Muckle creeks) are recognized as important to the Red River fishery, as well as providing irrigation water for agricultural land and for the Netley Creek golf course.

DEVILS CREEK:

Located on the east side of the Red River, just south of the Netley Marsh area, Devils Creek also has been identified as important habitat for many fish species. Since much of the upper watershed has been channelized or otherwise altered, the lower watershed is more extensively used for spawning activity in the spring.

COOK'S CREEK:

The creek originates near Richer and discharges into the Red River near Selkirk. Major land uses in the area include the agricultural production of crops, as well as pasture and livestock operations.

3.0 WATERSHED DESCRIPTION

3.1 CLIMATE

The Winnipeg area climate is characterized as mid-continental sub-arctic with hot dry summers and cold dry winters. Tables 1 and 2 summarize the monthly average temperature and precipitation data for the Winnipeg region.

TABLE 1: Monthly average (1951-1980) temperature (°C) data for the Winnipeg area (10).

MONTH	DAILY MAX TEMP.	DAILY MIN TEMP.	DAILY AVG. TEMP.
January	-14.3	-24.2	-19.3
February	-10.1	-21.0	-15.6
March	- 2.8	-13.5	- 8.2
April	8.9	- 2.2	3.4
May	18.0	4.5	11.3
June	23.1	10.5	16.8
July	25.9	13.3	19.6
August	24.7	11.6	18.3
September	18.4	6.3	12.4
October	11.5	0.7	6.1
November	- 0.3	- 8.6	- 4.5
December	- 9.4	-18.6	-14.0
Year Avg.	7.8	- 3.4	2.2

TABLE 2: Monthly average (1951-1980) precipitation data for the Winnipeg area (10).

MONTH	RAINFALL (mm)	# DAYS WITH RAIN	SNOWFALL (cm)	# DAYS WITH SNOW
January	0.2	-	23.7	12
February	0.7	1	18.9	9
March	3.3	2	21.1	9
April	27.1	5	11.3	4
May	63.2	10	2.5	1
June	80.1	11	Trace	-
July	75.9	11	0.0	0
August	75.2	11	0.0	0
September	53.0	11	0.2	-
October	25.9	7	5.2	2
November	5.5	2	21.9	9
December	0.9	1	20.7	11
Year Totals	411.0	72	125.5	57

3.2 DEMOGRAPHICS

A large portion of Manitoba's population resides within the classification area. Table 3 lists population estimates for Winnipeg and Selkirk, and the municipalities within the classification area (11, 12, 13).

TABLE 3: Population estimates for major cities and municipalities within the classification area.

CITIES/TOWNS	POPULATION	YEAR
Winnipeg	625,315	1989
Selkirk	9,905	1989

MUNICIPALITIES	POPULATION	YEAR
St. Andrews	12,544	1988
St. Clements	7,129	1988
East St. Paul	4,039	1988
West St. Paul	2,344	1988
Tache	6,679	1986
Ritchot	4,588	1986
Cartier	2,924	1986
Macdonald	3,583	1986
Springfield	9,836	1986
Rockwood	1,300	1986

A rural residential report of the Winnipeg region concluded that rural residential development in the Winnipeg region is concentrated along the Red, Assiniboine and Seine rivers in the Rural Municipalities of Tache, Ritchot, East and West St. Paul, St. Andrews and St. Clements, and scattered in the north west section of the R.M. of Springfield (14). These municipalities have witnessed intense rural residential development between 1976 and 1988 (14).

3.3 GENERAL ECONOMIC BASE

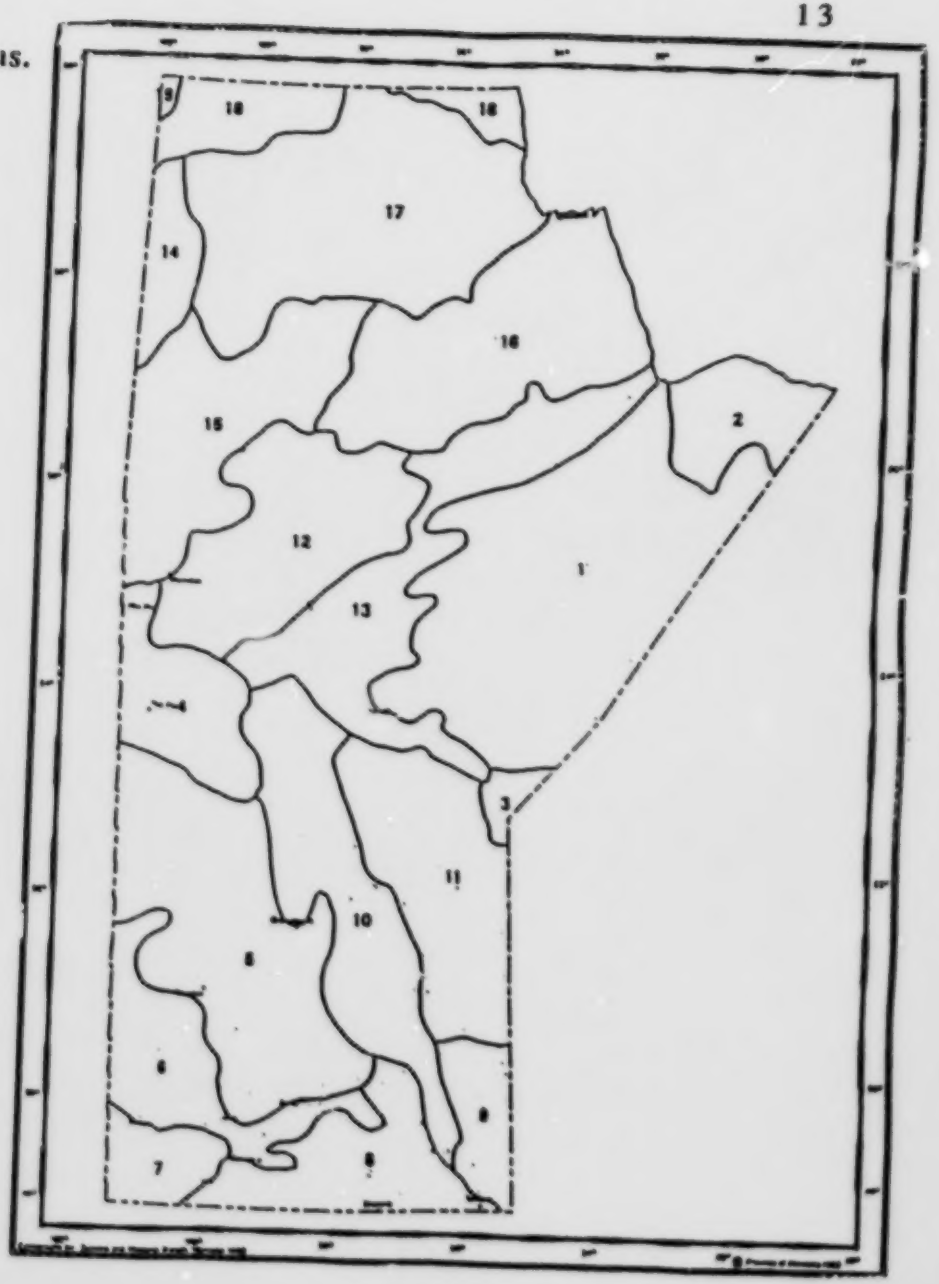
Within the area defined by this study, the economic base consists primarily of manufacturing, service industries and agriculture. Agricultural activities within this portion of the drainage basin include market gardening, mixed farming, livestock operations and cereal crop production. Agricultural land not in crop production is in summer fallow, pasture land or vacant woodlots.

3.4 HYDROLOGY

RED AND ASSINIBOINE RIVERS:

The classification area includes portions of two of Manitoba 19 watersheds, the Assiniboine River and Red River watersheds (Figure 3). The drainage area of the Red River upstream of the Assiniboine River at St. Norbert is 124,300 km^2 and near Lockport the drainage area increases to approximately 287,500 km^2. Approximately one third of Winnipeg's waters arrive via the Assiniboine River system, and two thirds via the Red River system. The majority of the flow in the Red River (64%) at Winnipeg, originates in the United States. Approximately 55% of the Assiniboine River flow originates in Manitoba (15). Downstream of the confluence of the Red and Assiniboine rivers at Lockport, the flow is described as 45% from Manitoba, 46% from the United States, and 9% from Saskatchewan (Figure 4). Environment Canada collects discharge data at a number of stations along the Assiniboine and Red

FIGURE 3: Manitoba's watershed basins.



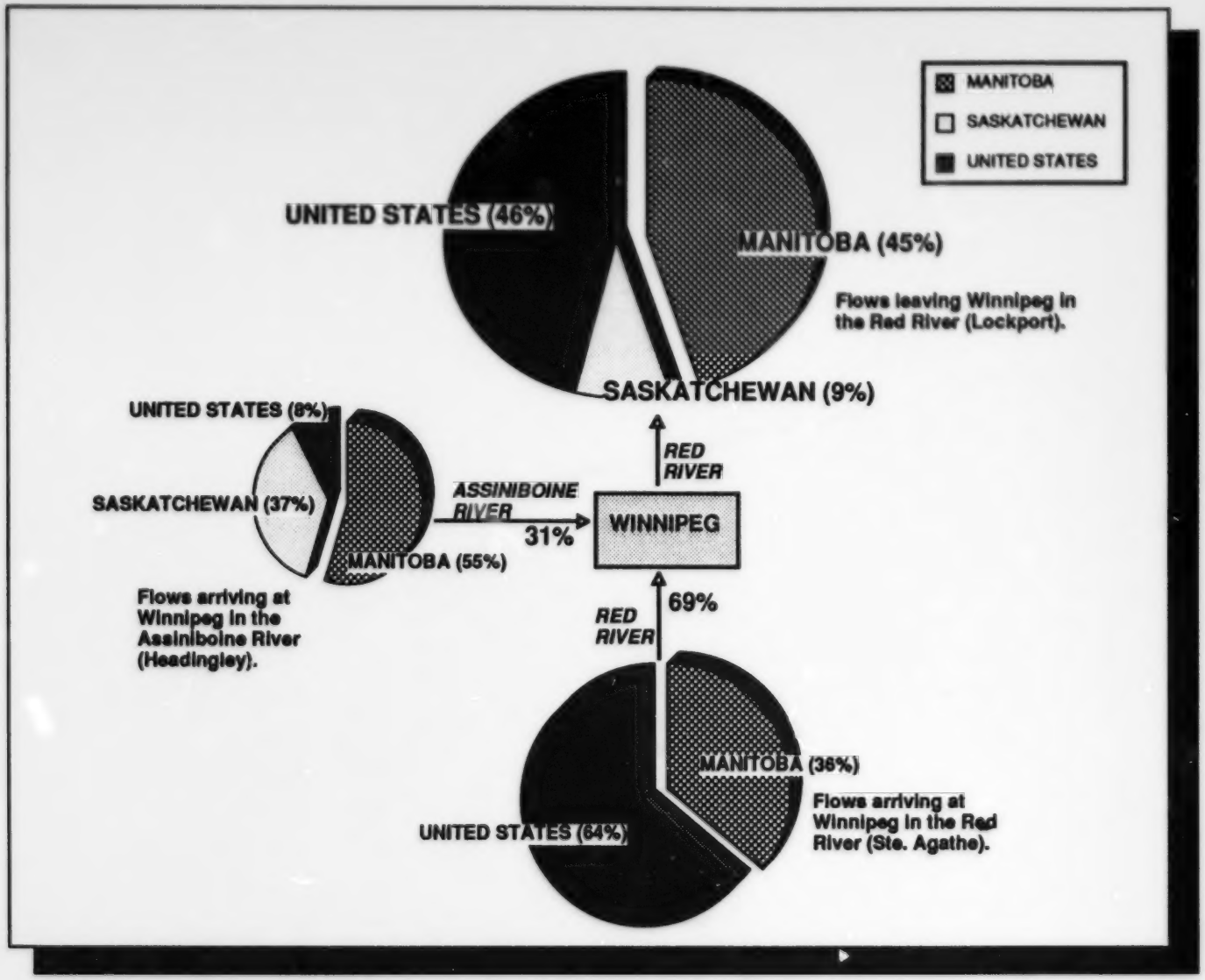


FIGURE 4: Compositional origin of flow in the Red and Assiniboine rivers near the City of Winnipeg (15).

rivers. Figure 5 illustrates the 1989 and long-term monthly average flow data collected from St. Agathe and Lockport on the Red River, and Headingley on the Assiniboine River (16). The majority of the runoff from these watersheds occurs during the spring. The flow rates are considerably higher during spring runoff at the Red River sites compared to the Assiniboine River site. During periods of high flow rates, the Red River floodway diverts water for approximately 47 km around Winnipeg where it is returned to the Red River just downstream of Lockport. The only other water level control structure, on this portion of the Red River, is located at Lockport. The Locks maintain higher water levels upstream in the Red and Assiniboine rivers which enhances recreational potential during the summer months, and allow boats to navigate the once tremendous rapids located at this site.

The quality of groundwater varies considerably throughout the area. In general, groundwater in the Headingley and St. Norbert area contains appreciable quantities of salt and is considered generally unsuitable for domestic consumption. On the eastern side of the Red River, the ground-flow is from the east with part of the recharge water originating in the Birds Hill area, and the balance in the eastern uplands. The water in the eastern and northwestern flow regions, which cross carbonate rock, is fresh in the recharge area and slightly brackish and very hard in the discharge area (17). These two systems are utilized for both rural and urban groundwater pumpage. The near-surface groundwater level is generally lowest during the winter months, increasing in April and May with snow melt and rainfall.

NETLEY MARSH:

The Netley-Libau Marsh is the delta of the Red River at its point of entry to Lake Winnipeg. The deposition of sediments and the reworking of existing sediments by the Red River and Lake Winnipeg have resulted in a complex network of channels, reversed deltas, natural levees and a beach ridge which form an intricate pattern of marsh land and lagoons. The marsh is not a delta in the normal sense since the sediments are not directly deposited by the river (18). Fine grain sediments held in suspension by currents and wave action in Lake Winnipeg are deposited in the marsh by openings in the beach ridge on Lake Winnipeg's southern shore. Water levels in the marsh are affected by both tributary flow and by Lake Winnipeg. Short-term fluctuations in water levels as great as 1 meter above mean levels occur due to wind setups on the lake.

The Netley Marsh area is drained to the east by the Brokenhead and Red River systems and to the west by the Netley, Wavey, Medicine and Muckle creek systems. The Red River flows through the Netley Marsh in a well-defined channel entering Lake Winnipeg via four separate channels. Many small channels branch from the river on its passage through the marsh. Netley Marsh consists of approximately 27,300 hectares of marsh and 13,600 hectares of marginal land.

TRIBUTARIES:

The hydrology of the tributaries have undergone considerable change as a result of residential and agricultural development. Table 4 details the current drainage area and the historic flow rates of the tributaries in the classification area.

STURGEON CREEK:

Stormwater drainage is directed to Sturgeon Creek via several outfall sewers (19). Although the creek is not subjected to discharge of raw sewage, some pollution to the creek occurs from urban wash (19).

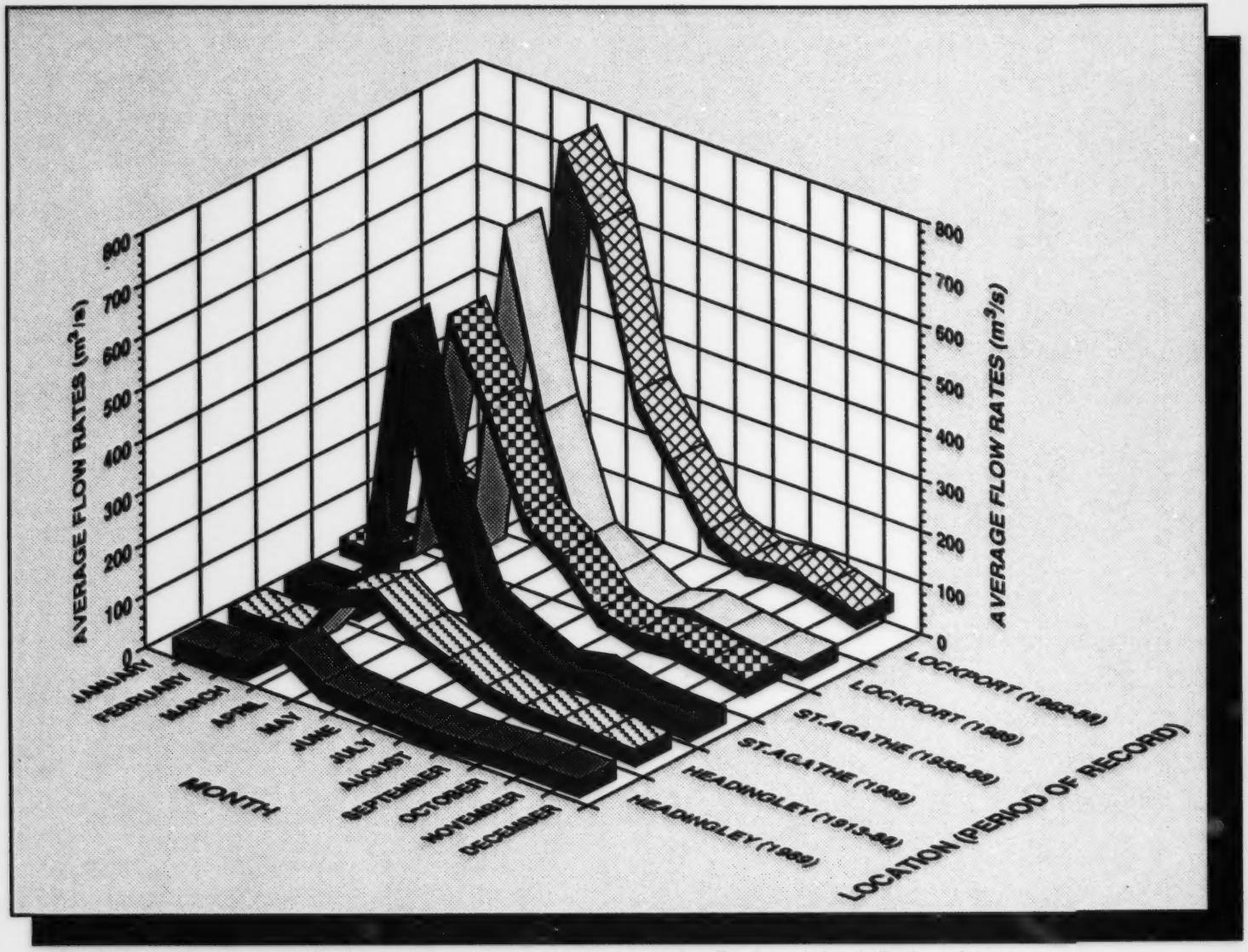


FIGURE 5: Average daily flow rates at three stations on the Red and Assiniboine rivers.

Sturgeon Creek experiences a wide range of flows. Spring melt and storm conditions have resulted in flows of about 67.5 m^3/s (19). It is estimated that flows of less that 0.14 m^3/s can be expected for 80% of the time between June 1 and September 30 (19). Flows of less than 0.03 m^3/s are estimated for 25% of the time during the same period.

Sturgeon Creek carries agricultural drainage from the northwest of the city, as well as urban stormwater from retention ponds. Extensive flooding occurred in the 1970's due to overloading of the creek by agricultural drainage (9). The diversion of some of this water and the enlargement of culverts on Portage Avenue have alleviated this problem

TABLE 4: Drainage area and monthly average flow rates for the tributaries of the Red and Assiniboine rivers within the study area.

TRIBUTARY WATERSHED	DRAINAGE AREA (km2)	AVG. MONTHLY FLOW (m^3/s) (yr)	FLOW MONITORING LOCATION
Lower Seine River Watershed	686.4	1.49 (1942-86)	Prairie Grove
Seine River Diversion Watershed	996.7	1.12 (1973-88)	Diversion-Ste. Anne
Cooks Creek watershed	709.7	1.92 (1957-88)	East Selkirk
		1.40 (1960-88)	Cook's Creek
		0.50 (1960-88)	Glass
Bunn's Creek Watershed	321.2	not monitored	
Lower La Salle River Watershed	768.2	2.42 (1922-88)	Sanford
Central La Salle River Watershed	636.2	0.47 (1979-88)	Elie
Sturgeon Creek and Omand's Creek	826.9		
	Sturgeon Creek	1.48 (1961-88)	St. James Street
	Sturgeon Creek	1.16 (1978-88)	Perimeter Hwy.
	Omand's Creek	0.16 (1978-88)	Brookside Cemetery
	Omand's Creek	0.19 (1978-88)	Metro Route 90
Grassmere Creek Watershed	473.3	0.73 (1963-88)	Middlechurch
Parks Creek Watershed	242.4	not monitored	
Devil's Creek Watershed	606.7	0.73 (1971-88)	Libau
Wavey Creek and Adjacent Watersheds	634.9	not monitored	
Netley Creek and Adjacent Watersheds	799.1	1.05 (1960-88)	Petersfield

OMAND'S CREEK:

The Omands-Colony Creek diversion of 1880 still exists in the same configuration originally excavated (9). The upper reach of Colony Creek (now Omand's Creek) is dammed within Brookside Cemetery to prevent downstream flooding. The creek north of Portage Avenue has been extensively encroached by industrial development. South of Portage Avenue, Omand's Creek is maintained close to its original state.

LA SALLE RIVER:

The La Salle River is a meandering stream which maintains a relatively low flow. Numerous dams are located along the entire length of the river. During periods of low flow, the river becomes a series of reservoirs. In 1984 an Assiniboine River diversion project was initiated to increase flow rates in the La Salle River. This diversion augments the natural river flow by approximately 0.70 m^3/s (20).

The hydrology of the river is impacted by the numerous dams located along the length of the river. Annual mean discharges recorded at Sanford are 2.42 m^3/s (16). Exchange of surface water and saline groundwater occurs in some reaches of the La Salle River during periods of low flow (21). The La Salle River empties in the Red River just north of the Floodway.

BUNN'S CREEK:

Bunn's Creek was designated a Provincial Waterway in the 1970's to protect it from encroachment and preserve it for both land drainage and recreational enjoyment (9). Extensive housing development has occurred, however the floodplains have been relatively well preserved between the Red River to Lagimodiere Boulevard. East of Lagimodiere, the watercourse changes to a straight drain, referred to as Cordite Ditch. The drainage area was substantially larger prior to the construction of the Red River Floodway. The Floodway now intercepts all agricultural run-off originating East of the Floodway.

The installation of storm sewers in Transcona, outletting to the Floodway, greatly reduced the inflow of drainage water from within the perimeter (22).

SEINE RIVER:

The Seine River was designated as a Provincial Waterway in the 1970's in recognition of its importance as a regional drain for rural and urban areas (9).

Extensive hydrologic alterations to the Seine River have occurred. The diversion of the natural flow regime resulted from the construction of the Red River Floodway which necessitated construction of a siphon under the Floodway. Downstream of Ste. Anne, the river frequently overtopped its banks until the Seine River Diversion was built in 1961. Flood flows of up to 85 m^3/s are diverted at Ste. Anne into a 35 km long floodway discharging into the Red River near St. Adolphe (23). During flood periods the control gates in the diversion dam are closed and the water in the Seine River ponds until it reaches an elevation of 251.16 m. Above this level the water flows down the diversion to the Red River. When flood waters recede, the control gates are opened to allow a flow of up to 1.4 m^3/s to maintain the Seine River's aesthetic value, as well as for the irrigation of lawns and vegetables (23).

Natural flows are generally much less than 1.35 m^3/s and may be negligible during July and August. During dry seasons, natural streamflow in the river has been inadequate to meet the needs of existing licensed water users located along the downstream reach of the river. Several users depend on pumping pools which have been created by small overflow weirs along the river. One of these weirs provides water for recreation and fire fighting in Ste. Anne. The remaining weirs are privately owned.

It has been estimated that future irrigation water use from the Seine River will double over the next 10 years. A doubling in demand is expected to result from

new market gardening operations and golf course irrigation (23).

The Manitoba Water Resources Branch recently requested that the Prairie Farm Rehabilitation Administration undertake a study to determine the most feasible means of increasing flows in the river. This study concluded that the most economic and feasible means of increasing flow may be to pump water from groundwater wells into the river (23). However, a more detailed hydrogeological study is required to quantify groundwater supply in this area.

3.5 GEOLOGY

The bedrock formations underlying the surface deposits of the Winnipeg area include rock types from Mesozoic era to the Precambrian, with the dominant rock types from Paleozoic era (17). Along the Red River south and north of Winnipeg, the dominant underlying rock is of the Red River Formation (Ordovician Period) consisting of dolomitic limestone. To the west of Winnipeg, rocks of the Stony Mountain Formation and Stonewall Formation (Ordovician Period) consist of calcareous shale, limestone and dolomites (17). The depth of surficial deposits over the bedrock vary from one to 60 meters. The deposits associated with glaciation are dominantly unconsolidated rock material derived from the rock formations through the actions of continental ice sheets and glacial melt water which covered the area during the Pliestocene epoch.

3.6 SOILS

The characteristics of the soil are determined by the physical and mineralogical composition of the original geological material, the climate under which the soil material has accumulated and existed, the biota on and within the soil, the relief and drainage that results from it, and the length of time the forces of development have acted on the geologic material (17).

Anthropogenic influences can also greatly alter the characteristics and the development of soils. The most important factors in soil formation are the temperature and moisture conditions. The soil climate varies significantly due to changes in topography and drainage. The soils in this region date back 7,000 to 8,000 years with the retreat of the waters from glacial Lake Agassiz. Over 100 soil types have been identified and mapped within the classification area. Generally, the soils in the area can be described as Chernozemic and Luvisols. A more detailed description of the soils in this area and their suitability for agriculture and other land use practices can be found in "Soils of the Winnipeg Area" (19).

4.0 WATER USES

The rivers and tributaries within the classification area serve a diversity of uses. These uses include both consumptive and non-consumptive activities.

The Water Resources Branch of Manitoba Natural Resources has the responsibility for allocation of the consumptive use and diversion of water resources within the Province. An individual or corporation who wishes to use water for agricultural, municipal and industrial, irrigation or other purposes must obtain a Water Rights Licence. Table 5 lists the water Rights Licences that have been issued within the boundaries of this study. A consumption rate of less than 25,000 L/day does not require a Water Right Licence. Some of these users may not be currently utilizing these water sources, and other users not listed in this table, may be utilizing river water without obtaining a water right licence.

The following sections will detail the current knowledge of water uses for the surface waters within the classification area.

TABLE 5: Water right licences issued by the Water Resources Branch of Manitoba Natural Resources.

LICENCE NO. (YR-NO)	WATER SOURCE	LOCATION	USE DESCRIPTION	LICENCE MAXIMUM m^3/YEAR
62-38	RED RIVER	ST. NORBERT	IRRIGATION-MARKET GARDENING	24,670
76-48	RED RIVER	ST. NORBERT	IRRIGATION-MARKET GARDENING	2,467
76-47	RED RIVER	ST. NORBERT	IRRIGATION-MARKET GARDENING & FARMING	19,736
62-10	RED RIVER	ST. NORBERT	IRRIGATION-MARKET GARDENING	20,969
62-11	RED RIVER	ST. NORBERT	IRRIGATION-MARKET GARDENING	55,507
75-06	RED RIVER	ST. NORBERT	IRRIGATION	7,401
79-21	RED RIVER	WINNIPEG	RECREATION-RECREATIONAL LAKE	96,212
88-11	RED RIVER	WINNIPEG	IRRIGATION-IRRIGATE GOLF COURSE	154,185
68-14	RED RIVER	WINNIPEG	IRRIGATION	55,507
77-66	RED RIVER	WINNIPEG	IRRIGATION & AIR CONDITIONING	44,405
-06	RED RIVER	WINNIPEG	INDUSTRIAL-COOLING PURPOSES	57,233,556
68-10	RED RIVER	WINNIPEG	IRRIGATION-IRRIGATE GOLF COURSE	98,679

TABLE 5: Continued.

LICENCE NO. (YR-NO)	WATER SOURCE	LOCATION	USE DESCRIPTION	LICENCE MAXIMUM m^3/YEAR
77-48	RED RIVER	ST. PAULS	IRRIGATION-IRRIGATE LAWNS	12,335
84-32	RED RIVER	ST. PETERS	IRRIGATION-IRRIGATE STRAWBERRIES	14,802
75-33	RED RIVER	ST. PETERS	IRRIGATION-IRRIGATE LAWNS	12,335
87-88	RED RIVER	ST. ANDREWS	IRRIGATION-IRRIGATE VEGETABLES & STRAWBERRIES	9,868
73-25	RED RIVER	ST. ANDREWS	IRRIGATION-IRRIGATE STRAWBERRIES	18,502
74-30	RED RIVER	ST. ANDREWS	IRRIGATION-MARKET GARDENING	18,502
72-10	RED RIVER	ST. ANDREWS	IRRIGATION-STRAWBERRIES, RASPBERRIES, PEPPERS	4,934
80-01	RED RIVER	ST. CLEMENTS	IRRIGATION-STRAWBERRIES	33,304
80-13	RED RIVER	SELKIRK	MUNICIPAL-WATER SUPPLY (SELKIRK)	4,193,838
90-21	RED RIVER	ST. CLEMENTS	IRRIGATION-NURSERY & GREENHOUSE (Trees & Shrubs)	49,339
88-06	RED RIVER	SELKIRK	INDUSTRIAL-THERMAL ELECTRIC GENERATION	352,981,786
65-04	RED RIVER	ST. ANDREWS	IRRIGATION-VEGETABLE GARDENING	27,137
65-09	RED RIVER	ST. PAULS	IRRIGATION-VEGETABLE GARDENING	4,934
64-35	RED RIVER	ST. ANDREWS	IRRIGATION-VEGETABLE GARDENING	9,868
87-12	RED RIVER	ST. PAULS	IRRIGATION-VEGETABLE GARDENING	6,167
-52	RED RIVER	ST. PAULS	IRRIGATION-MARKET GARDENING	74,009
-02	RED RIVER	WINNIPEG	INDUSTRIAL-MANITOBA SUGAR	unknown
89-48	RED RIVER	ST. NORBERT	IRRIGATION-VEGETABLE GARDENING & TREES	9,868
00-11	ASSINIBOINE R.	WINNIPEG	IRRIGATION-IRRIGATE LAWNS	30,220
68-12	ASSINIBOINE R.	WINNIPEG	IRRIGATION-DUCK-POND & ENGLISH GARDENS	6,167
85-53	ASSINIBOINE R.	WINNIPEG	IRRIGATION-IRRIGATE GOLF COURSE	209,692
84-50	ASSINIBOINE R.	HEADINGLEY	IRRIGATION-STRAWBERRIES & VEGETABLES	61,674

TABLE 5: Continued.

LICENCE NO. (YR-NO)	WATER SOURCE	LOCATION	USE DESCRIPTION	LICENCE MAXIMUM m^3/YEAR
81-38	ASSINIBOINE R.	WINNIPEG	IRRIGATION-FARMLAND	271,366
79-33	ASSINIBOINE R.	ST. FR. XAVIER	IRRIGATION-STRAWBERRIES & VEGETABLES	8,634
62-21	ASSINIBOINE R.	HEADINGLEY	IRRIGATION-MARKET GARDENING	296,036
89-95	ASSINIBOINE R.	HEADINGLEY	IRRIGATION-IRRIGATE GOLF COURSE	185,022
88-20	ASSINIBOINE R.	WINNIPEG	IRRIGATION-IRRIGATE TREE NURSERY	61,674
70-28	ASSINIBOINE R.	WINNIPEG	IRRIGATION-IRRIGATE LAWNS	12,335
89-94	ASSINIBOINE R.	WINNIPEG	IRRIGATION-IRRIGATE SHRUBS, TREES, BEDDING PLANTS	43,172
68-13	SEINE RIVER	WINNIPEG	IRRIGATION-IRRIGATE GOLF COURSE	98,679
84-45	SEINE RIVER	WINNIPEG	IRRIGATION-IRRIGATE GOLF COURSE	123,348
89-114	SEINE RIVER	WINNIPEG	IRRIGATION-IRRIGATE STRAWBERRIES	12,335
80-08	LA SALLE R.	ST. NORBERT	IRRIGATION-IRRIGATE CROPS & DOMESTIC CONSUMPTION	49,339
81-52	LA SALLE R.	ST. NORBERT	IRRIGATION-MARKET GARDENING	61,674
89-107	LA SALLE R.	ST. NORBERT	IRRIGATION-IRRIGATE GOLF COURSE	92,511
88-34	LA SALLE R.	ST. NORBERT	IRRIGATION-STRAWBERRIES & RASPBERRIES	18,502
86-55	LA SALLE R.	ST. NORBERT	IRRIGATION-STRAWBERRIES	8,634
81-32	COOKS CREEK	ST. PETERS	IRRIGATION-STRAWBERRIES, RASPBERRIES, & ASPARAGUS	18,502
78-27	COOKS CREEK	ST. CLEMENTS	IRRIGATION-MIXED VEGETABLE GARDENING	18,502
82-48	COOKS CREEK	ST. CLEMENTS	IRRIGATION-CORN & STRAWBERRIES	12,335
90-22	COOKS CREEK	ST. CLEMENTS	IRRIGATION -NURSERY & GREENHOUSE	37,004
81-33	COOKS CREEK	ST. CLEMENTS	IRRIGATION-ALFALFA, HAY, CORN	123,348

TABLE 5: Continued.

LICENCE NO. (YR-NO)	WATER SOURCE	LOCATION	USE DESCRIPTION	LICENCE MAXIMUM m^3/YEAR
89-31	NETLEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE GOLF COURSE	43,172
81-39	NETLEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE BLUE GRASS, HAY	123,348
73-27	NETLEY CREEK	ST. CLEMENTS	IRRIGATION- IRRIGATE STRAWBERRIES	6,167
85-46	NETLEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE STRAWBERRIES	6,167
87-28	WAVEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE GOLF COURSE	9,868
81-35	WAVEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE ALFALFA & HAY	123,348
77-12	WAVEY CREEK	ST. CLEMENTS	IRRIGATION-IRRIGATE ALFALFA	135,683
85-2	BUNN'S CREEK	WINNIPEG	IRRIGATION-IRRIGATE STRAWBERRIES	3,700
65-6	OMAND'S CK.	WINNIPEG	IRRIGATION-IRRIGATE LAWNS	4,934

4.1 DOMESTIC CONSUMPTION

Manitoba Surface Water Quality Objectives have been established to ensure the protection of waters that are suitable for human consumption. Inherent in these objectives is the necessity to disinfect all raw surface water supplies as a minimum treatment prior to consumption. Other treatment processes are also required when the domestic consumption objectives are exceeded. Within the classification area, only the Red and the La Salle rivers are used as a domestic water source.

RED RIVER:

Within the defined area of the Red River, only Selkirk utilizes the river as a domestic water supply. The town of Selkirk draws water from two wells and supplements this supply with Red River water when consumption demands exceed that supplied by the wells. Tables 6 and 7 summarize typical total water consumption quantities in 1989, and the approximate portion of the 1985-1991 consumption attributable to the Red River.

In May of 1991 Selkirk reverted to 35% Red River water due to a mechanical failure in one of the wells. There is potential for future use of the Red River as a domestic water supply for the town of Selkirk. Selkirk may continue to draw on Red River water to supplement the water obtained from their existing wells. Also, river water may be utilized in the event that further maintenance or repair work is required for the well operations. An expansion of ground water supply is planned through the addition of two wells.

The Selkirk water treatment facility includes pre-chlorination, lime treatment and potassium permanganate treatment. Post chlorination of the treated water occurs prior to distribution.

TABLE 6: Typical 1989 water consumption values (m^3) for the town of Selkirk.

MONTH	MAX. DAY	MIN. DAY	AVG. DAY	MONTH TOTAL
April	4794	2411	4171	125,123
May	5934	3998	4661	144,650
June	5663	4177	4940	153,134

TABLE 7: Summary of Red River water intake for domestic consumption between 1985-1991.

DATE	PORTION BLENDED
May 27-Sept.12, 1985	50% River & 50% Wells
May 31-Sept. 9, 1986	60% River & 40% Wells
May 20-Oct. 16, 1987	Blend unknown
June 10-Aug. 8, 1988	25% River & 75% Wells
1989-1990	Red River not used
May-Aug 1991*	35% River & 65% Wells

* As of August 1991.

LA SALLE RIVER:

A domestic water plant is located at Sanford on the La Salle River. The plant utilizes both La Salle River water and diverted Assiniboine River water to supply a population of approximately 1040. The Sanford plant currently serves the communities of Sanford, Domain, La Salle and Oak Bluff. Expansion of the distribution network is under consideration.

4.2 AQUATIC LIFE AND WILDLIFE

The Manitoba Surface Water Quality Objectives are intended to ensure the protection of both the aquatic community as well as semi-aquatic animals, such as waterfowl, shorebirds, furbearing mammals and other water orientated wildlife including the necessary aquatic organisms in their food chain. Protection of waters suitable for watering wild animals is also provided.

4.2.1. FISHERIES:

The surface waters within the classification area support a cool water fishery. The Manitoba Surface Water Quality Objectives define objectives that ensure the passage, maintenance and propagation of fish species which are indigenous to a cool water habitat (3).

4.2.1.1. RED AND ASSINIBOINE RIVER FISHERIES:

RED RIVER:

The Red River supports a diverse population of cool water fish. A total of 46 fish species are found in the Red River upstream of the Lockport Dam, while 50 species have been noted downstream of the Lockport Dam. The species assemblage downstream of Lockport is somewhat different than upstream. For example, lake sturgeon, lake whitefish and cisco are not found upstream of Lockport (24). Tagging studies on fish in the Red River have indicated that there is extensive

fish movement in the river. Catfish tagged near Selkirk have been recaptured in North Dakota (24). Carp, catfish, sauger, walleye and suckers have been observed using the Lockport Dam fishway. Table 8 lists the fish species found upstream and downstream of Lockport.

NETLEY-LIBAU MARSH:

The Netley-Libau Marsh is a dynamic and unique fish habitat in the Lake Winnipeg-Red River area. The marsh provides spawning, nursery and feeding areas for Red River and Lake Winnipeg fish populations, supporting three of Manitoba's most profitable fisheries (18). The fish community is both diverse and abundant during the open water season, with the species composition changing seasonally.

Of the 25 most common species in the marsh, the most valuable and abundant fish are yellow perch, shiners, sauger, goldeye and northern pike. These fish are important for their commercial, sport and or historical fisheries value. Young-of-year are abundant during summer, not only from species which spawn in the marsh, but also from species whose eggs and larvae reach this area by passive drift.

In winter, much of the marsh is frozen to the bottom and most fish species move into the Red River and Lake Winnipeg, although some species are able to overwinter in deeper marsh channels.

During the open water season young-of-year feed on algae, zooplankton and immature stages of aquatic insects. Based on phosphorous levels and chlorophyll *a* levels, the Netley Marsh lakes have a potential fish productivity which is three to four times higher per unit area than the south basin of Lake Winnipeg (18).

ASSINIBOINE RIVER:

It is expected that fish species in the Assiniboine River would be much the same as for the Red River upstream of Lockport, at least for part of the year (24). When flows in the Assiniboine are reduced, the river may not be as suitable for many of the larger fish species. Catfish, sauger, goldeye, freshwater drum and walleye fishing are known to occur along the banks of the Assiniboine River within Winnipeg.

4.2.1.2. TRIBUTARY FISHERIES:

Detailed information on the fisheries of most of the tributaries is limited. Spawning is known to occur in those tributaries where gravel bars and adequate water exists.

OMAND'S CREEK:

The fisheries in Omand's Creek is one of the smallest and most severely impacted, and therefore can be used as a minimum indicator of aquatic life density and diversity in other tributaries.

During a study conducted from April to October 1983, four species of fishes were recorded in the creek (25). Northern pike and white sucker enter the creek from the Assiniboine River in the spring during spring run-off when water levels in the creek are high. The observations of small pike in the summer months suggests that successful spawning occurred in the creek in 1983. White sucker were also observed spawning and a large school of fry were seen in June. Creek chub and brook stickleback are smaller fish which are year round residents of the creek.

TABLE 8: Species list of fish found upstream and downstream of Lockport in the Red River (24).

SPECIES	UPSTREAM of LOCKPORT	DOWNSTREAM of LOCKPORT	SPECIES	UPSTREAM of LOCKPORT	DOWNSTREAM of LOCKPORT
Chestnut Lamprey	P	P	White Sucker	P	P
Silver Lamprey	P	P	Bigmouth Buffalo	P	P
Lake Sturgeon	A	P*	Silver Redhorse	P	P
Lake Whitefish	A	P	Golden Redhorse	P	P
Cisco	A	P	Shorthead Redhorse	P	P
Brook Trout	A	P**	Black Bullhead	P	P
Rainbow Trout	A	P**	Brown Bullhead	P	P
Arctic Char	A	P**	Channel Catfish	P	P
Rainbow Smelt	A	P	Stonecat	P	P
Goldeye	P	P	Tadpole Madtom	P	P
Mooneye	P	P	Trout-perch	P	P
Northern Pike	P	P	Burbot	P	P
Central Mudminnow	P	P	Banded Killifish	P	A
Carp	P	P	Brook Stickleback	P	P
Goldfish	P	A	White Bass	P	P
Spotfin Shiner	P	P	Rock Bass	P	P
Silver Chub	P	P	Bluegill	P	A
Golden Shiner	P	P	White Crappie	P	A
Emerald Shiner	P	P	Black Crappie	P	P
River Shiner	P	P	Johnny Darter	P	P
Common Shiner	A	P	Iowa Darter	P	P
Spottail Shiner	P	P	Blackside Darter	P	P
Sand Shiner	P	A	River Darter	P	P
Hornyhead Chub	P***	A	Log Perch	P	P
Flathead Chub	A	P	Sauger	P	P
Fathead Minnow	P	P	Walleye	P	P
Longnose Dace	A	P	Freshwater Drum	P	P
Quillback Suckers	P	P	TOTALS=	46	50

P=Species Present, A=Species Absent.

* Based on occurrence of Lake Sturgeon in Lake Winnipeg.

** Occasional specimens from the Rockwood Fish Hatchery at Gunton find their way to the Red River via Wavey and Netley creeks.

*** Rainbow smelt have been found in the south basin of Lake Winnipeg; occasional specimens may turn up in the lower Red River.

Schools in excess of 500 fish were common in all areas by mid-summer. By late August their population along a one km stretch was estimated at 10,000 (25). The absence of large creek chub suggest that over-wintering survival rates are low. In late June, large numbers of brook stickleback were observed amongst the aquatic vegetation. By late summer, their numbers were estimated to equal or surpass the number of chub.

STURGEON CREEK:

In the spring, Sturgeon Creek serves as a spawning area on the Assiniboine River. It has been reported that a large number of suckers ascend the creek in spring. Species such as silver redhorse, shorthead redhorse, white sucker and perhaps golden redhorse may be involved in these spawning runs (24). Angling may occur at the mouth of the creek in spring. Brook stickleback and fathead minnows have also been reported in the creek. It is expected that these species occupy the upper reaches of the creek year round (24).

LA SALLE RIVER:

Upstream movement of fish into the La Salle River from the Red River has been limited by the presence of the La Barriere dam (24). The common sucker, fathead minnow, five-spine stickleback, central mudminnow and rock bass have been found in the river (26). White crappies have also been reported in the lower reaches of the La Salle River (24). It is expected that little if any recruitment of fish occurs from the Assiniboine River diversion. Some angling occurs between the La Barriere dam and the Red River.

DEVILS CREEK:

Devils Creek flows into Upper Devils Lake within the Netley-Libau Marsh. Black crappie, brown bullhead, burbot, carp, channel catfish, emerald shiner, freshwater drum, goldeye, northern pike, rock bass, sauger, tadpole madtom, trout-perch, walleye, white bass and white sucker have been found in Devil's Creek (24).

Most of the large fish species are found only in the lower reach of the creek. Much of the upper reaches of this creek have been channelized or otherwise altered and are not adequate to support large fish species. It is expected that fish utilization of Devil's Creek would be greatest in April and May, and possibly June, depending on the timing of spring breakup (24).

COOK'S CREEK:

Cook's Creek provides spawning, nursery and feeding habitat for fish populations integral to those stocks exploited by commercial, sport and bait fisherman working the lower Red River and its tributaries. A good diversity of species has been identified in this tributary. These include bigmouth buffalo, black crappie, brown bullhead, burbot, carp, central mudminnow, channel catfish, chestnut lamprey, cisco, emerald shiner, freshwater drum, golden shiner, goldeye, johnny darter, mooneye, northern pike, quillback sucker, rock bass, sauger, shorthead redhorse sucker, spottail shiner, tadpole madtom, trout-perch, walleye, white bass, white sucker, yellow perch and goldfish (24). The most valuable of these species are the walleye, sauger, pike and sucker.

It is believed that the thermal electric effluents from the East Selkirk thermal generating station have allowed for the overwinter survival of goldfish. The majority of species listed above are probably limited to the lower reach of the creek between its mouth and Highway #59. Gravel bars in other parts of the creek, especially around bridges, may also provide spawning habitat for walleye and suckers (24).

The extensive marshy habitats near the mouth of the creek are believed to provide excellent spawning conditions for northern pike. Operation of Manitoba Hydro's East Selkirk thermal electric generating plant in the winter of 1987-88 resulted in a fishkill in Cook's Creek below the plant's thermal outfall. Large numbers of trophy sized channel catfish, as well as some other species were involved in this kill. Subsequent thermal shock fishkills in the creek were averted by placing a net across the mouth of the creek, effectively excluding fish from the creek. However, this solution has resulted in loss of fish habitat (24).

Fish movement into Cook's Creek is greatest between the April and June period when the major species are moving into the system to spawn. Dipnetting occurs along the creek banks during this time of the year (24). Fish are also attracted into the creek during the winters by the higher temperature, but as indicated above, these fish are now excluded from moving into the creek.

In Dubas Creek, a tributary of Cook's Creek, brook stickleback, mudminnows, pike, common suckers, carp, brown bullhead, sauger and walleye have been observed. Some of these species have been identified during spawning migrations (27).

NETLEY-WAVEY-MUCKLE CREEKS:

Netley Creek is known to support the following fish species: bigmouth buffalo, black crappie, brook trout, brown bullhead, burbot, carp, channel catfish, emerald shiner, golden shiner, goldeye, northern pike, rock bass, sauger, spottail shiner, walleye, white bass, white sucker and yellow perch (24). Netley creek provides an important spawning area for pike, walleye, suckers and bullheads (27).

Much of Wavey Creek has been channelized to improve the drainage of agricultural land in the area. Fish surveys indicate that Wavey Creek supports channel catfish, brown bullhead, freshwater drum, northern pike, walleye, white sucker and yellow perch. Muckle Creek, a tributary of Netley Creek, supports black crappie, brown bullhead, carp, channel catfish, cisco, emerald shiner, freshwater drum, goldeye, northern pike, sauger, walleye, white bass, white sucker and yellow perch. These three creeks provide both winter and open water angling opportunities. A sport fishing lodge is located near the mouth of Netley Creek.

BUNN'S CREEK:

There is one report of pike and suckers entering the creek during spring spawning movements (27). It is expected that some of the smaller species, such as those found in Omand's Creek, may also be present in Bunn's Creek.

SEINE RIVER:

The use of the Seine River for spawning by fish populations in the Red River is not known (27). Fathead minnows, brook sticklebacks and tadpole madtom have been collected from the Seine River near the Floodway. Carp have also been found in the river.

OTHER TRIBUTARIES:

The Fisheries Branch does not have any specific data on the smaller tributaries within the classification area. It is anticipated that intermittent streams would not support significant populations, although some may have enough flow in the spring to allow for the spawning of pike and suckers. This would be particularly true for those streams located nearest to the Netley Marsh area (24). There is no information for

Grassmere Creek. Since this stream has been significantly altered, Fisheries Branch believes it would support only small species such as minnows or sticklebacks.

4.2.2. OTHER AQUATIC LIFE AND WILDLIFE:

4.2.2.1. RED AND ASSINIBOINE RIVERS:

In addition to the important fishery downstream of Winnipeg, other aquatic life and wildlife make use of this riparian habitat which offers both wildlife cover and food. Two significant areas include the Netley Marsh area on the Red River and the Beaudry area on the Assiniboine River

A variety of amphibians and reptiles have been inventoried along the Red River north of Winnipeg. Over 100 migratory and permanent bird species have been identified, with some of these species excavating holes in the steep mud banks of river for nesting (28). Although a variety of waterfowl species can be seen along the entire length of the river, significant numbers occur primarily in the Netley Marsh area. This is an important staging, migrating and breeding area. Muskrat and beaver activity occurs within this portion of the drainage basin, with less activity occurring upstream of the Netley area. Both small and large mammals use wooded and shrub riverbank habitat for shelter and food. Examples of these mammals include white-tailed deer, raccoons, mink, weasels, squirrels, bats and voles (28).

4.2.2.2. TRIBUTARIES:

Detailed information on the aquatic life of most of the tributaries is unavailable. Therefore, the aquatic life and wildlife in Omand's Creek which is one of the smallest and most severely impacted tributaries, is used as a minimum indicator of aquatic life and wildlife density and diversity in other tributaries.

OMAND'S CREEK:

An investigation of the wildlife of Omand's Creek was undertaken in response to proposed developments along the creek (25). The investigation found that Omand's Creek supports a complex community of plants and animals. It serves as a small oasis for wildlife within an urban environment. The study, conducted from April to October in 1986, identified and recorded the diversity of wildlife found along the section of the creek stretching from Portage Avenue to St. Matthews Avenue. Within the 8.5 ha. study site, 153 species of higher plants were identified. These species were categorized as 25 species of trees and shrubs, 80 species of herbaceous perennials, 37 species of herbaceous annual or biennials, and 11 species of emergent and aquatic plants. Among this list was a significant array of true prairie species (25).

Invertebrate species identified include two species of leeches, four species of snails, one species of crayfish and numerous species of insects, including 19 species of butterflies.

The four species of amphibians found in the study area were wood frogs, boreal frogs, leopard frogs and the Canadian toad. The western painted turtle was the only reptile recorded during the investigation. Five species of mammals were observed. It was estimated that 20 to 30 Richardson's ground squirrels, one thirteen-lined ground squirrel, one beaver, 15 to 20 muskrats, and an undetermined number of meadow voles inhabit this portion of Omand's Creek.

Seventy-one species of birds were encountered during this study. Successful breeding was obtained for 12 of these species. Herons, kestrels and sandpipers were a few of the species observed foraging in the creek. Next to the house sparrow, mallards were the most frequently observed species. Five mallard hens raised broods in the creek (25).

4.3 INDUSTRIAL CONSUMPTION:

Where applicable, the Manitoba Surface Water Quality Objectives provide for "the protection of all waters which are or may be used as a source of supply for industrial processes or cooling water, or any other industrial or commercial purposes and for which quality control is or may be necessary" (3). Discharges or alterations to waters classified for industrial consumption should not be permitted such that downstream present or potential users will incur unacceptable additional treatment costs. Objectives will be developed when necessary, using industry specific requirements outlined in the Canadian Water Quality Guidelines (29). Modifications to these guidelines may be required for site specificity (3).

Within the classification area, industrial consumption of surface water is limited, as indicated in Table 9.

TABLE 9: Industrial consumption of surface water in the classification area.

INDUSTRY	USE	SOURCE
Manitoba Sugar (Winnipeg)	Cooling water	Red River
Manitoba Hydro (Selkirk)	Cooling water	Red River

4.4 IRRIGATION USES:

Manitoba Surface Water Quality Objectives have been established for water used for agricultural consumption. The objectives define maximum acceptable levels of quality for greenhouse irrigation, as well as for field crop irrigation and livestock watering (3).

Within the classification area, a number of greenhouse, and fruit and market gardeners use river water as either a sole or supplementary source of irrigation water. The objectives established for these uses, ensure the protection of humans from the harmful effects caused by the accumulation of substances on marketable produce which may not be washed prior to consumption (39). The objectives, established for these uses, also provide long-term protection of soils from the accumulation of substances that may be harmful or cause a reduction in fertility.

4.4.1. AGRICULTURAL IRRIGATION:

Many commercial and domestic gardening and horticulture operations are located beside rivers and streams to gain access to an inexpensive water supply. Table 10 lists the larger commercial greenhouse operations, and market and fruit gardeners, within the classification area.

It is also known that the Red and Assiniboine rivers and their tributaries, are utilized for noncommercial gardening and lawn watering. Establishing the extent of this use is difficult since water right licences are not normally required unless the consumption rate exceeds 25,000 litres per day. Although not quantified in this report, the capacity for extensive use for this purpose is recognized.

TABLE 10: Greenhouse, fruit and vegetable irrigation use within the classification area.

NAME	LOCATION	WATER SOURCE	CROP IRRIGATED
Loganberg Gardens	Main St. Wpg.	Red River	Vegetables
Prazinik's Fruit & Vegetable Market	Lockport	Red River	Fruit & Vegetables
Foxberry Farms	Selkirk	Red River	Strawberries
Paul's Greenhouse	St.Vital, Wpg.	Red River	Bedding plants, starter vegetables
Riverside Greenhouse Ltd.	St Mary's Rd, Wpg.	Red River	Bedding plants
Foxberry Farms	Selkirk	Red River	Strawberries
Strawberry Patch	Selkirk	Red River	Strawberries, raspberries
Dome Market Gardens & Nursery	Headingley	Assiniboine River	
Paterson A.R. Greenhouses	Headingley	Assiniboine River	Bedding plants
Paterson E.D. Greenhouses	Headingley	Assiniboine River	Bedding plants, starter vegetables
Paterson D.J. Greenhouses	Headingley	Assiniboine River	Bedding plants, fruit & vegetables
Shelmerdine Nurseries and Garden Centre	Roblin Blvd, Wpg.	Assiniboine River	Bedding plants, prop. of cuttings
Ken's Berry Patch	Ste. Annes	Seine R. Diversion	Strawberries, raspberries
Grossman Strawberry Farm	Lorette	Seine River	Strawberries
La Salle Valley Berry Farm	St. Norbert	La Salle River	Strawberries, raspberries
De Groot	St. Clements	Cook's Creek	Strawberries

4.4.2. PARK AND GOLF COURSE IRRIGATION:

Many river bank parks utilize river water for irrigation or landscaping enhancement. The City of Winnipeg and many private golf clubs utilize river water for irrigation of golf courses. Although some of this irrigation occurs over night, daytime irrigation of golf courses and parks brings into concern the microbiological quality of the irrigation water.

Tables 11 and 12 detail river usage by both City of Winnipeg and private golf clubs within the classification area. Although some of these golf clubs hold river water in retention ponds prior to use on the golf course, many use river water directly for irrigation upon withdrawal.

TABLE 11: River use for the irrigation of City of Winnipeg public golf courses (30).

CITY OF WINNIPEG GOLF COURSES	WATER SOURCE	QUANTITY USED (est. million L/year)	IRRIGATION PERIOD (hrs used)
Kildonan Park (Winnipeg)	Red River	231.5	Day & Night (14 hrs)
Crescent Drive (Winnipeg)	Red River	122.6	Day & Evening (10 hrs)
Windsor Park (Winnipeg)	Seine River	231.5	Night only
John Blumburg (Headingley)	Assiniboine River	281.5	Day & Night (14 hrs)

TABLE 12: River use for the irrigation of private public golf courses.

PRIVATE GOLF COURSES	WATER SOURCE	QUANTITY USED (est. million L/year)	IRRIGATION PERIOD (hrs used)
Southwood (Winnipeg)	Red River	not metered	85% night, 15% day
Wildwood (Winnipeg)	Red River	not metered	Morning
Winnipeg Canoe Club (Winnipeg)	Red River	not metered	75% night, 25% day
Selkirk Golf Course (Selkirk)	Red River	not metered	Evening and night
Larter Golf Course (St. Andrews)	Red River	not metered	Mostly night, morning, day
Charleswood (Winnipeg)	Assiniboine River	•	•
Glendale (Winnipeg)	Assiniboine River	not metered	Night only
St. Charles (Winnipeg)	Assiniboine River (retention ponds)	not metered (max=3.41)	Mostly night, also day
St. Boniface (Winnipeg)	Seine River	not metered	night only
Niakwa (Winnipeg)	Seine River (retention ponds)	not metered	night only (10pm-5am)
Netley Creek (Petersfield)	Netley Creek	•	•

• information unavailable.

This data indicates that many courses irrigate during the day. Irrigation water which comes in contact with staff and golfers should not contain high levels of fecal coliform. The Manitoba Surface Water Quality Objectives recommend a maximum fecal coliform density of 200 organisms/100 mL for irrigation water which comes into direct contact with humans.

City of Winnipeg community and regional parks utilize river water for irrigation and landscape enhancement. Surface waters are also used for cemetery irrigation. Table 13 details the usage of surface water for these purposes.

TABLE 13: City of Winnipeg community and regional parks, and cemetery grounds estimated river water usage (31).

SITE	SOURCE	USE	EST. QUANTITY (L/yr)	TIME OF USE
Assiniboine Park	Assiniboine R.	duck pond, irrigation of gardens	38,000,000.	24 hrs/day, May-Oct.
Maryland Bridge Site	Assiniboine R.	park irrigation	4,280,000.	9:00am-2:00pm, May-Sept.
John Blumberg Park	Assiniboine R.	park irrigation	10,206,000.	8:30am-3:30pm, May-Sept.
Stephen Juba Park	Red R.	park irrigation	2,041,200.	8:30am-3:30pm, May-Sept.
Bonnycastle Park	Assiniboine R.	park irrigation	3,061,800.	8:30am-3:30pm, May-Sept.
Fraser's Grove Park	Red R.	park irrigation	2,041,200.	8:30am-3:30pm, May-Sept.
St. Vital Park	Red R.	duck ponds, park irrigation	112,300,000.	8:30am-4:00pm, May-Oct.
Whittier Park	Red R.	park irrigation	5,184,000.	8:30am-3:30pm May-Sept.
Cresent Drive Park	Red R.	park irrigation	2,073,600.	8:30am-3:30pm May-Sept.
King's Park Park	Red R.	park irrigation, ornamental lake	137,443,000.	24 hrs/day May-Oct.
St. Vital Cemetery	Red R	cemetery irrigation	3,939,480.	8:00am-9:00pm, May-Sept.
Brookside Cemetary	Omand's Ck.	cemetery irrigation	not metered	Daylight hours, June-Sept.

The timing of irrigation indicates that contact with irrigation water by persons using the park is probable. On hot sunny days, children and adults may intentionally or accidently come in contact with irrigation water.

In some cases this water may contain high levels of pathogenic and nonpathogenic organisms. It is possible that children may drink water from sprinkler systems, not knowing it is unsafe to do so.

4.5 RECREATION

Manitoba Surface Water Quality Objectives have been developed for the protection of surface waters used for recreational activities (3). The objectives for this use classification have been divided into two categories:

A. PRIMARY RECREATION:

This category defines objectives that will ensure the protection of waters which are suitable for recreational activities where the human body may come into contact with the water, to the point that water may be ingested accidently or water may come in contact with sensitive organs such as the eyes, ears and nose. Examples of such activities include wading, dabbling, swimming, diving, water-skiing, surfing, tubing or jet-skiing.

B. SECONDARY RECREATION:

This category defines objectives that will provide protection to waters which are suitable for boating, fishing and other water related activities other than immersion recreation, including navigation and aesthetic enjoyment of scenery. This category provides protection for activities in which water use is incidental, accidental or sensory. Such activities include boating, fishing, camping, hunting and hiking.

The property adjacent to the rivers and creeks within the classification area is used for such diverse recreational activities as walking, pleasure driving, picnicking, fishing, boat launching, bicycling, nature walking, bus touring, tobogganing, snowshoeing, snowmobiling and cross-country skiing (32).

The rivers and creeks themselves are used for a number of activities. These can include water skiing, swimming, power boating, canoeing, rowing, jet-skiing, fishing (including ice fishing), commercial tour boating, houseboating, skating, snowmobiling and cross-country skiing.

An extensive survey of recreation use of the lower Red River extending from Winnipeg to Lake Winnipeg was conducted in 1976. The survey revealed that this area received approximately 50,000 visiting groups in June, July and August (32). The report states that sightseeing, picnicking, fishing, swimming, and visiting historic sites are very popular recreation activities among both residents and visitors. It is anticipated that the number of visitors to this area has increased since 1976, as development of the recreational opportunities continue to expand.

The following sections detail the information obtained on both primary and secondary recreational activities within the classification area.

4.5.1. PRIMARY RECREATION:

The Red and Assiniboine rivers are infrequently used for swimming. Winnipeg's Harbour Master has indicated that some children go into the river for the

novelty, and that transients living along the riverbanks also occasionally use the river for bathing. The turbidity of the water and the steepness of the banks, make swimming in the rivers somewhat dangerous as well as undesirable.

Although the microbiological quality of the Red River if often significantly poorer than the primary recreation water quality objective, the river is frequently used for other body contact activities. Between Winnipeg and Selkirk there are four organized water-skiing clubs using the river for both recreation and competitive training. Within Winnipeg, there are five or six ski-jumps and slalom courses on the Red River. Water-ski lesson are also given on the Red River. The shallow depth of the Assiniboine river prevents its use for water-skiing activity.

Water-ski and jet-ski rentals are available within and downstream of Winnipeg. The Harbour Master has estimated that there are approximately 30 jet skis routinely used on the Red River (33).

4.5.2. SECONDARY RECREATION:

4.5.2.1. SPORT FISHING:

RED RIVER:

The area of the river between Lockport and Lake Winnipeg is the most popular fishery in Manitoba (34). This area is attractive to anglers not only because of its proximity to Winnipeg, but also due to the varied angling experience it offers. The Red River provides a quality of fishing, measured in catch per unit effort, that is very high relative to other road-accessible fisheries in southern Manitoba.

It has been estimated that the Red River receives up to 15% to 20% of Manitoba's resident licensed angler efforts based on the 1980 sport fishery survey (18). Local anglers have fished the fall run of large walleye for many years, however its popularity has increased significantly since the start of the 1980's (34). A portion of this increased fishing activity has been attributed to the promotion of trophy catfish and walleye fishing (34). The Manitoba Tourism Department and businesses in Selkirk and Lockport have also promoted the fishery. The value of the sport fishery on the Red River was estimated to be $6.5 million dollars in 1985 (24).

The Lake Winnipeg-Red River bait fishery is also one of Manitoba's foremost fisheries. Estimates suggest that 60% to 70% of Manitoba's bait fish production, worth $300,000 annually, is harvested in this area (18).

The Red River fishery has three major components. The first constituent is the fall and winter walleye that annually move into the river in September and October. Secondly, a significant fishery is concentrated on the large channel catfish that congregate in the river, primarily in May, June and July. The last component of the fishery consists of general angling for all species of fish in the river.

The Red River is the second most valuable Manitoba sport fishing water for trophy size goldeye (18). The harvest of large catfish, primarily by sport fishermen, may be beyond the level that will sustain this trophy fishery into the indefinite future (34). The harvest of large walleye may similarly exceed the level that will ensure the currently viable trophy fishery indefinitely. These fish are currently being harvested by sport, commercial and domestic fisheries (34).

Recently, concern has arisen over the increased pressure on all three segments of the fishery. Local anglers and merchants have expressed concerns regarding the over-harvest of the fishery (34). In

response to these concerns, the Red River Advisory Group was formed to develop a fisheries management plan which would provide a basis for long term allocation and management decisions. This plan, developed in 1988, is intended to maximize net benefits from the fishery, while minimizing resource use conflicts.

A creel survey of anglers exploiting the Red River from the St. Andrews locks at Lockport to the mouth of Netley Creek was conducted during the open water season in 1982 (35). One of the objectives of this survey was to quantify spatial and temporal changes in species numbers and weights of fish harvested from the river. This survey also quantified spatial and temporal changes in angling effort. This survey estimated angling effort exerted at Lockport, Selkirk and Netley Creek during the 1982-1983 angling season to be 336,626 angler hours. A total of 85% of these hours were spent during the open water season, with 15% of the effort occurring during the winter. Red River anglers removed 112,445 kg of fish from the river during the 1982 to 1983 season.

This harvest comprised approximately 2.8% of the entire Manitoba angling harvest (35). Age specific mean lengths and weights of Walleyes were very similar to those observed during the 1982 Lake Winnipeg commercial stock assessment program, implying that the walleye and sauger exploited in the Red River were members of the southern Lake Winnipeg stock. Increase in the abundance of freshwater drum in the river were attributed to increases in turbidity along the Red and Assiniboine rivers (35). Walleye are highly preferred by many anglers in spite of the fact they are not the dominant species. Fewer anglers utilize areas upstream from the Lockport dam since these preferred species are less abundant in this area (35). Table 14 details the estimates of the total number and weight of fish removed from this portion of the Red River between May and October in 1982:

TABLE 14: Results of a creel census conducted on the Red River between Lockport and Netley Creek from May 15 to October 30, 1982 (35).

SPECIES	NUMBER OF FISH	WEIGHT OF FISH (kg)
WALLEYE	7,833	10,110
SAUGER	94,033	20,762
DRUM	51,316	47,348
GOLDEYE	40,357	7,951
PIKE	358	493
SUCKER	706	494
CATFISH	1,486	9,934
BULLHEAD	1,430	551
BURBOT	265	267
ROCK BASS	101	24
CARP	935	4,440
MOONEYE	88	13
WHITE BASS	1,089	394
PERCH	483	74
TOTAL=	200,480	102,855

Another creel census was conducted in 1988 to 1989, this time quantifying the number of boats, boat anglers and shore anglers. This creel survey, conducted in the area between Lockport and Lake Winnipeg, illustrates the extensive recreational use of this stretch of the river for sport fishing during the open water season (Table 15). Both boat anglers and shore anglers contributed significantly to these high use numbers (36).

The data from the two creel surveys indicate that the Red River fishery is both popular and rewarding. The economic benefits of the sport fishery on the Red

River are significant to businesses in the local community, in Winnipeg, and in the province as a whole. The Red River Advisory Board has recommended that these economic benefits should be maintained or, where possible, expanded (34).

TABLE 15: Recreational fishing use numbers for the Red River between Lockport and Lake Winnipeg for the open water season, based on 1988/1989 creel survey conducted by the Fisheries Branch of Manitoba Natural Resources (36).

MONTH	TIME OF WEEK	MEAN # OF BOATS	MEAN # OF BOAT ANGLERS	MEAN # OF SHORE ANGLERS
MAY	Weekend	61	166	434
	Weekday	18	45	128
JUNE	Weekend	39	117	173
	Weekday	12	31	95
JULY	Weekend	54	142	264
	Weekday	12	36	72
AUGUST	Weekend	40	120	210
	Weekday	10	32	68
SEPTEMBER	Weekend	75	204	147
	Weekday	32	112	60
OCTOBER	Weekend	101	284	87
	Weekday	49	140	46
TOTALS:	May-Oct	9,468	26,588	33,665

NETLEY MARSH:

At present there is little fishing in Netley Marsh proper, however the fish species in the marsh are valuable to the Lake Winnipeg commercial gillnet industry which harvests 37% of Manitoba's total fish production. Netley Marsh is also important to the Red River sport fishery which receives 15% to 20% of resident angling effort, and the Red River-Lake Winnipeg bait fishery which yields 60 to 70% of Manitoba's bait fish production. Fishing in the marsh is limited due to poor access, complex topography, and current fisheries regulations (18). Commercial bait fishing activity does occur in the marsh proper.

ASSINIBOINE RIVER:

Angling in the Assiniboine River is less prevalent than in the Red River. Angling in the Assiniboine is concentrated at the mouth of the river, and at the mouths of such tributary streams as Sturgeon Creek during spring runoff. Shoreline angling takes place from a number of public access points. Fish species sought in the Assiniboine River would be much the same as for the Red River upstream of Lockport (24).

TRIBUTARIES:

Sport fishing occurs in many of the tributaries within the classification area. Devil's, Wavey and Cook's creeks have been utilized for both sport and commercial fishing (18). Sturgeon Creek and the La Salle River also support a limited sport fishery (24).

4.5.2.2. BOATING:

Boating use of the Red and Assiniboine rivers is extensive and appears to be increasing. The Harbour Master has estimated that between 1988 to 1989, there was an increase of 25% in the number of persons and boats using the river (37). On a Saturday or Sunday with clear weather, the Harbour Master has estimated there to be about 200 moving boats at any given time during

daylight hours. During a Variety Club Poker Derby, approximately 300 boats were active. These estimates only include the boating activity south of the north perimeter, and do not include the Lockport or Selkirk areas. Information gathered by the Province of Manitoba and the City of Winnipeg, indicated that between Winnipeg and Selkirk there were approximately 50,000 individuals using the Red or Assiniboine rivers for power boating, canoeing or rowing in 1990.

Within Winnipeg, canoe and rowing clubs use the river for both recreation and competitive training. Canoeing lessons, races and canoe-a-thons are also held on the rivers. The Harbour Master believes that canoeing use of the rivers is increasing. He has estimated that there may be as many as 20 canoes on the rivers each day (33).

The Red River provides a base for three yacht clubs and at least six commercial tour boats.

4.5.2.3. SPECIAL EVENTS:

A number of special events have been held on the Red and Assiniboine rivers during both the summer and winter months. Recent summer events include the Western Canada Summer Games, bath tub races, power boat races, raft races, regattas, rubber duck races and fishing derbies. During the winter, ice fishing derbies, cross-country ski competitions, and car and motorcycle ice racing are also held on the rivers.

4.5.2.4. RIVERSIDE PARKS:

Many river bank parks support or facilitate recreational activities that fall under the classification of primary or secondary recreation. Examples of these activities include power boating, rowing, canoeing, fishing, wading, dabbling, hiking or camping. Expansion of riverbank park development is anticipated to increase participation in these primary and secondary recreational activities. Since the City of Winnipeg continues to acquire riverbank property, it is expected that in the future, more river access points will become available for recreation. Winnipeg's Harbour Master believes that with the increased emphasize on river bank use, there will be an increase in river use (33). For the assurance of both public health and aesthetic enjoyment, recreational water quality objectives should be maintained in the surface waters adjoining riverbank parks.

An example of recent riverbank renewal, includes the 13 million dollar Canada-Manitoba Agreement for Recreation and Conservation (ARC), which resulted in the implementation of 18 riverbank projects along the Red River (38). These projects included, among others:

1. St. Boniface Dock
2. Stephen Juba Park
3. River Road Enhancement
4. Netley Creek Nature Area
5. The Forks National Historic Site

In 1986, the second Winnipeg Core Area Initiative Agreement was signed. The agreement marked the first initiative by all three levels of government. Two programmes under the Core Area Agreement were targeted for riverbank renewal: a 20 million dollar program to redevelop the CN East Yards (The Forks), and a 5 million dollar programme to enhance the Core Area's riverbanks (38). Recently, the City of Winnipeg announced a planned expenditure of 11 million dollars to purchase additional river property near the Forks.

In 1985, Manitoba announced a riverbank

development program. Under this program, the creation of the Bluestem Nature Park on Omand's Creek and the development plan for the south Legislative grounds have been undertaken (38).

The City of Winnipeg is continuing to purchase riverbank property along the Seine River for the development of a linear park. The park development is expected to increase the current extent of recreational use of the area.

Within the classification area, a number of riverbank parks accommodate recreational opportunities and many provide direct access to the river via docks and launching facilities. Table 16 lists some of the larger parks located adjacent to waterways within the classification area. In addition to those listed in the table, a large number of small undeveloped parks and green-spaces, many acquired by the City, also provide recreational opportunities along the banks of these waterways.

4.5.2.5. CAMPING AND PICNICKING:

Camping and picnicking occur in the Netley Creek area. The Breezy Point Picnic Ground and Netley Creek Picnic and Campground located along the west bank of the Red River are provincially owned.

In addition to the picnic areas within riverbank parks, waysides along River Road provide picnic sites along the Red River.

4.5.2.6. HUNTING:

Numerous hunting lodges are scattered throughout the Netley Marsh area (8). Duck hunting is concentrated in the northern reaches of the Red River.

TABLE 16: Riverbank parks located adjacent to waterways within the classification area.

RIVERBANK PARKS	LOCATION	WATER BODY
CHURCHILL DRIVE PARK	WINNIPEG	RED RIVER
CRESCENT DRIVE PARK	WINNIPEG	RED RIVER
ELM PARK	WINNIPEG	RED RIVER
FRASER GROVE PARK	WINNIPEG	RED RIVER
THE FORKS	WINNIPEG	RED RIVER
KILDONAN PARK	WINNIPEG	RED RIVER
KINGS PARK	WINNIPEG	RED RIVER
LYNDALE DRIVE PARK	WINNIPEG	RED RIVER
MAPLE GROVE PARK	WINNIPEG	RED RIVER
RIVER ROAD WAYSIDES	WINNIPEG	RED RIVER
TACHE & PROMENADE	WINNIPEG	RED RIVER
ST. JOHN'S PARK	WINNIPEG	RED RIVER
ST. VITAL PARK	WINNIPEG	RED RIVER
STEPHEN JUBA PARK	WINNIPEG	RED RIVER
GUAY PARK	WINNIPEG	RED RIVER
ST. NORBERT PROV. PARK	ST. NORBERT	RED RIVER
QUEENS PARK	SELKIRK	RED RIVER
SELKIRK PARK	SELKIRK	RED RIVER
MUNICIPAL PARK	SELKIRK	RED RIVER
BREEZY POINT PARK	ROCKWOOD	RED RIVER
NETLEY CREEK PARK	ROCKWOOD	RED RIVER
ASSINIBOINE PARK	WINNIPEG	ASSINIBOINE R.
JOHN BLUMBERG PARK	HEADINGLEY	ASSINIBOINE R.
STURGEON CREEK PARK	WINNIPEG	STURGEON CR.
GRANT'S MILL PARK	WINNIPEG	STURGEON CR.
WOODHAVEN PARK	WINNIPEG	STURGEON CR.
OPTIMIST PARK	WINNIPEG	STURGEON CR.
AMARYNTH PARK	WINNIPEG	STURGEON CR.
OMAND'S CREEK PARK	WINNIPEG	OMAND'S CR.
BLUE STEM NATURE PARK	WINNIPEG	OMAND'S CR.
LA BARRIERE PARK	WINNIPEG	LA SALLE R.
SHERWOOD FOREST	WINNIPEG	LA SALLE R.
BUNN'S CREEK PARK	WINNIPEG	BUNN'S CR.

4.5.3. CALCULATION OF RECREATIONAL IMMERSION EVENTS ON THE RED AND ASSINIBOINE RIVERS:

The estimates of immersion events (*i.e.* body contact events) in the Red and Assiniboine rivers were derived from five information sources. These sources consist of the following:

1. Estimates given by the Harbour Master.
2. A random telephone survey conducted by the City of Winnipeg in 1990.
3. A telephone survey, conducted by Manitoba Environment, of clubs and organizations using the river for recreation or training activities.
4. Aerial survey conducted by the City of Winnipeg in 1990.
5. Estimates of river use compiled by the City of Winnipeg in 1986.

Primary recreation activities include swimming, water-skiing, tubing, and jet-skiing. For such activities, one immersion event was counted for each time an individual participated in that activity in any given day. It was estimated that a total of 4200 primary recreation immersion events occurred in the Red River during 1990 (Table 17).

The results of the Red Cross Small Craft Safety Needs Assessment study were utilized to calculate the expected frequency of immersion events resulting from secondary recreational activities (39). The Red Cross study found that the probability of an individual having an immersion event while boating, over a season, was 5%. This percentage was used to estimate the expected number of immersions which would result from boating activity in 1990. For the Red and Assiniboine rivers within the classification area, it was estimated that of the 46,000 boaters, 2300 could be expected to have at least one immersion event during 1990. For the Winnipeg and Selkirk areas, the number of immersion events resulting from primary and secondary activities, was estimated at 6500 (Table 17).

It should be noted that no data was available to estimate the number of immersion events which may result from riverbank fishing. Data from a 1988 to 1989 creel census conducted by Manitoba Department of Natural Resources indicate that between May and October, approximately 34,000 people use the banks of the Red River between Lockport and Lake Winnipeg for sport fishing (36). The data compiled in Table 17 does not include any estimate of immersion rate for this activity. Similarly there were no data available to estimate the number of people who may intentionally or accidently become immersed in river water from other riverbank recreation activities.

4.5.4. OTHER RIVERBANK RECREATION ACTIVITIES:

4.5.4.1. HISTORIC SITES:

The banks of the river are also home to a number of museums and historical sites. A few of the most prominent historic sites include St. Andrews Church, St. Peter's Church, Scott House, Twin Oaks, Lower Fort Gary National Historic Park, Selkirk Marine Museum, St. Peter's Church and La Salle River Property.

TABLE 17: Estimated immersion (body contact) events in the Red and Assiniboine rivers between April and October of 1990.

RECREATION ACTIVITY	IMMERSIONS WINNIPEG	IMMERSIONS SELKIRK	TOTALS
PRIMARY RECREATION: (Swimming, water-skiing, jet-skiing)	3800	400	4200
SECONDARY RECREATION: (Motor boating, canoeing, rowing)	1900	400	2300
GRAND TOTALS =	5700	800	**6500**

4.5.4.2. GOLF AND COUNTRY CLUBS:

A number of golf and country clubs are located adjacent to streams within the classification area. In addition to enhancing the aesthetics, these rivers provide a source of irrigation water (Table 11 and 12) to many of the golf courses listed in Table 18.

TABLE 18: Golf and country clubs located adjacent to rivers within the classification area.

GOLF AND COUNTRY CLUBS	LOCATION	SURFACE WATER
SOUTHWOOD GOLF & COUNTRY CLUB	WINNIPEG	RED RIVER
WINNIPEG GOLF & CANOE CLUB	WINNIPEG	RED RIVER
WILDWOOD GOLF & COUNTRY CLUB	WINNIPEG	RED RIVER
CRESCENT DRIVE GOLF COURSE	WINNIPEG	RED RIVER
LARTER GOLF COURSE	ST.ANDREWS	RED RIVER
SELKIRK GOLF COURSE	SELKIRK	RED RIVER
GLENDALE GOLF COURSE	WINNIPEG	ASSINIBIONE R.
ST. CHARLES GOLF COURSE	WINNIPEG	ASSINIBIONE R.
CHARLESWOOD	WINNIPEG	ASSINIBOINE R.
ST. BONIFACE GOLF COURSE	WINNIPEG	SEINE RIVER
WINDSOR PARK GOLF COURSE	WINNIPEG	SEINE RIVER
NIAKWA GOLF COURSE	WINNIPEG	SEINE RIVER
NETLEY CREEK GOLF COURSE	ROCKWOOD	NETLEY CREEK

4.6 DOMESTIC WASTEWATER DISCHARGE:

By the 1930's, pollution and disease from contaminated surface water became a concern of Greater Winnipeg residents. With a population of 300,000., upwards of 15 million gallons of raw sewage entered the river each day. During some months, the sewage flow equalled the river flow (40). These conditions led to the establishment of the Greater Winnipeg Sanitary District in 1935, and before the end of the decade, sewage was receiving primary treatment at the North End Plant. Since this time, the wastewater

treatment facilities have been upgraded or expanded in an attempt to accommodate the increasing population.

Under the previous Clean Environment Act, the City of Winnipeg had authority, by Order-in-Council No. 152/72, to regulate discharges to surface water within the City of Winnipeg and the Additional Zone. Under the new Environment Act, enacted March 31, 1988, the delegated authority was removed and the City became subject to licensing by the Province.

Municipal and private wastewater discharges are listed in Tables 19 to 21. The City of Winnipeg contributes the largest quantity of effluent discharge to the Red and Assiniboine rivers through its three sewage treatment plants (*i.e.* the North, West and South End Water Pollution Control Centres).

The North End Water Pollution Control Centre (NEWPCC) has a primary sewage treatment capacity which is 2.75 times greater than the average dry weather flow. This primary capacity is 827 million litres/day. The secondary treatment processes a maximum of 2.0 times the average dry weather flow, with a capacity of 598 million litres/day.

The West End Water Pollution Control Centre (WEWPCC) consists of a series of facultative lagoons (three primary cells and two secondary cells) and an extended aeration mechanical treatment plant. The extended aeration plant has a peak capacity of 27 million litres/day. Flows above this capacity are diverted to the lagoons. The effluent from the mechanical treatment is discharged to one of the secondary lagoon cells in the winter to cool the effluent in order to reduce open water on the Assiniboine River.

TABLE 19: Domestic wastewater dischargers within the Assiniboine River.

OPERATING AUTHORITY	RECEIVING WATER	NATURE OF DISCHARGE*
CITY OF WINNIPEG-WEWPCC	ASSINIBOINE R.	MC
ASSINIBOIA CAMP	ASSINIBOINE R.	NML
BARICKMAN COLONY	ASSINIBOINE R.	NML
BIG SKY TRAVEL SHOP	ASSINIBOINE R.	NMC
BREEZY BEND GOLF COURSE	ASSINIBOINE R.	NMC
CAMP MANITOU	ASSINIBOINE R.	NMC
CANADIAN FORCES BASE	ASSINIBOINE R.	NMC
GLENORCHIE TRAILER PARK	ASSINIBOINE R.	NMC
HEADINGLEY JAIL	ASSINIBOINE R.	NMC
JOHN BLUMBERG GOLF COURSE	ASSINIBOINE R.	N.MC
TANSI RESORTS INC.	ASSINIBOINE R.	NMC

* NMC=non-municipal continuous, MC=municipal continuous, NML=non-municipal lagoon, ML=municipal lagoon.

TABLE 20: Domestic wastewater dischargers within the Red River.

OPERATING AUTHORITY	RECEIVING WATER	NATURE OF DISCHARGE*
LOCKPORT SCH. LAGOON	RED RIVER	N M L
BIRD'S HILL PARK-PARKS BRANCH	RED RIVER	N M L
CITY OF WINNIPEG-NEWPCC	RED RIVER	M C
CITY OF WINNIPEG-SEWPCC	RED RIVER	M C
DR. F.W.L. HAMILTON SCHOOL	RED RIVER	N M C
G. ZIELKE RESIDENCE	RED RIVER	N M C
HIGHWAY GARDENS TRAILER PARK	RED RIVER	N M L
LISTER RAPIDS DEVELOPMENT	RED RIVER	M C
LOCKPORT SCHOOL	RED RIVER	N M L
MANITOBA SUGAR	RED RIVER	N M C (SEPT-JAN)
MELODY LANE TRAILER PARK	RED RIVER	N M C
MIDDLECHURCH HOME	RED RIVER	N M C
PINE RIDGE VILLAGE-KEASCHELL PARKS LTD	RED RIVER	N M L
RIVERCREST DEVELOPMENT	RED RIVER	M C
RIVERDALE DEVELOPMENT	RED RIVER	M C
SEVEN OAKS SCHOOL DIVISION	RED RIVER	N M C
SISTERS OF THE ORDER OF BENEDICT	RED RIVER	N M C
ST. ANDREWS SCHOOL	RED RIVER	N M C
ST. JOHN'S CATHEDRAL SCHOOL	RED RIVER	N M C
TOWN OF SELKIRK	RED RIVER	M C
VILLAGE OF BIRDS HILL	RED RIVER	M L
VILLAGE OF BIRDS HILL-HODDINOT	RED RIVER	M C
WEST ST. PAUL SCHOOL	RED RIVER	N M C

* NMC=non-municipal continuous, MC=municipal continuous, NML=non-municipal lagoon, ML=municipal lagoon.

TABLE 21: Domestic wastewater dischargers within the tributaries.

OPERATING AUTHORITY	RECEIVING WATER	NATURE OF DISCHARGE*
HAPPY THOUGTH SCH. LAGOON	COOK'S CREEK	N M L
OAKBANK LAGOON	COOK'S CREEK	M L
TYNDALL LAGOON	DEVILS CREEK	M L
STONEWALL LAGOON	GRASSMERE DRAIN	M L
ELIE LAGOON	LA SALLE RIVER	M L
ELIE WATER PLANT DISCHARGE	LA SALLE RIVER	M L
GRAND COLONY LAGOON	LA SALLE RIVER	N M L
JAMES VALLEY COLONY LAGOON	LA SALLE RIVER	N M L
LA SALLE LAGOON	LA SALLE RIVER	M L
OAK BLUFF LAGOON	LA SALLE RIVER	M L
OAKVILLE LAGOON	LA SALLE RIVER	M L
SANFORD LAGOON	LA SALLE RIVER	M L
STAR LITE FARMS LTD LAGOON	LA SALLE RIVER	N M L
STARBUCK LAGOON	LA SALLE RIVER	M L
INTERLAKE COLONY LAGOON	NETLEY CREEK	N M L
NEW HAVEN LAGOON	PARKS CREEK	N M L
CONCORD COLONY LAGOON	PARKS CREEK	N M L
LA BROQUERIE LAGOON	SEINE RIVER	M L
LORETTE LAGOON	SEINE RIVER	M L
BLUMENORT LAGOON	SEINE RIVER	M L
MANITOBA HYDRO DORSEY ST.	STURGEON CREEK	N M
WARREN LAGOON	STURGEON CREEK	M L

* NMC=non-municipal continuous, MC=municipal continuous, NML=non-municipal lagoon, ML=municipal lagoon.

The South End Water Pollution Control Centre (SEWPCC) is a secondary sewage treatment facility. Primary treatment capacity is 112 million litres/day, with a secondary capacity of 82 million litres/day.

The three plants are served by 2140 kilometers of sewers and interceptors, and 96 pumping stations. Expansion of the north end sewage treatment facility has been recently completed. Expansion of the south end plant has been approved by the Manitoba Environment, and expansion of the west end sewage treatment plant has been proposed by the City of Winnipeg.

The treated wastes from the City of Winnipeg's sewage treatment facilities are discharged to the Red and Assiniboine Rivers. Currently there is no disinfection sewage to destroy the bacteria and viruses before this waste is discharged into the rivers.

In the case of wet weather events where the capacities of the treatment facilities are exceeded, storm water and raw sewage bypass the plants and flow directly into the rivers without treatment. The frequency of these exceedences is dependent on the number of significant rain events. These occurrences average approximately 30 times a year. Raw sewage discharge into the rivers may last up to several days depending upon the magnitude of the precipitation event.

In addition, approximately 20 private treatment facilities discharg effluent into the waters within the classification area. Many municipalities also discharge sewage effluent to the rivers and streams, in accordance with standards set out in environmental licences.

In the older areas of Winnipeg, sewers were constructed to handle both sanitary sewage and stormwater runoff. Since 1969 new housing developments have separate stormwater and sanitary sewers. Stormwater in these areas is directed to a retention pond or into a river system. Approximately 50% of Winnipeg is serviced by combined sewers.

4.7 INDUSTRIAL WASTEWATER DISCHARGE:

Major industrial operations having point source wastewater discharge are listed in Table 22. Many of these operations discharge cooling water into the receiving stream.

Where the potential for a negative impact on the fishery is anticipated, site specific temperature guidelines can be specified in the Environment Licence for the operation of the plant

4.8 OTHER RIVER USES:

Other river uses, not detailed in the above sections, include commercial float plane use and commercial freighting.

TABLE 22: Industrial discharge within the classification area.

OPERATION	RURAL MUNICIPALITY	NATURE OF DISCHARGE	RECEIVING WATER
Manitoba Hydro-Dorsey Converter Station	Rosser	Cooling water	Sturgeon Creek
Union Carbide of Canada Ltd.	St. Andrews	Continuous-septic effluent, cooling tower blowdown	Red River
Manitoba Rolling Mills	St. Andrews	Continuous-process wastewater, septic effluent	Red River
Manitoba Hyrdo-Selkirk Generating Station	St. Clements	Continuous-cooling water, fly ash pond overflow, septic effluent, plant drainage.	Cook's Creek, Red River
Dow Corning Plant •	St. Clements	Continuous cooling water blowdown	Cook's Creek
Interlake Potato Farms	Rockwood	Intermittent-process wash water	Netley Creek via ditch
Manitoba Sugar	Winnipeg	Cooling water only (Sept-Jan.)	Red River

• Not yet operational (as of March 1991).

5.0

PROPOSED CLASSIFICATION:

MANITOBA SURFACE WATER QUALITY OBJECTIVES:

Manitoba Environment is proposing Water Quality Objectives be established to protect beneficial existing and potential water uses. Manitoba Environment will put forth this Water Classification proposal to the Clean Environment Commission hearings this fall. By releasing the proposal at this time, the department hopes to encourage interest and involvement in the hearings, and at the same time provide a point of reference to initiate public discussion and debate.

The final recommendations of the Clean Environment Commission, which operates independent of the department, will be based on all the information presented at the public hearings.

The proposed classification of the Red River, Assiniboine River, Seine River, La Salle River, Sturgeon Creek, Omand's Creek, Bunn's Creek, Cook's Creek, Netley Creek and Devil's Creek is detailed in Table 23. Other smaller tributaries which have not been classified, can also be afforded protection if important water uses are identified. This proposal has been developed on the basis of both the potential and existing water uses.

A 'Routine' level of protection is proposed for all surface waters within the classification area (2). The routine level of protection, which normally applies to water bodies which may have been affected by development to some degree, consists of the following combination:In the case of multiple use designation, the surface water is afforded protection according to the most sensitive use.

The following provides a general description of the proposed classification of surface waters as detailed in Table 23:

Class 1: Domestic Consumption:

This classification proposes that the Red and La Salle rivers be protected for domestic consumption use. Currently these are the only two surface waters, within the classification area, being used as a source of drinking water. These objectives will ensure the protection of waters that are used for human consumption after treatment.

Class 2B: Cool Water Aquatic Life and Wildlife:

It is proposed that all the rivers and tributaries be classified for the protection of cool water aquatic life and wildlife. These objectives will ensure the protection of aquatic life such as fish, amphibians, reptiles and other forms of life including aquatic insects and algae. By ensuring protection of the aquatic communities, protection is indirectly afforded to those forms of wildlife that rely upon surface waters for habitat and for food supplies. These include ducks, geese, furbearing mammals such as muskrats. Protection is also provided to those animals that use these waters for drinking purposes.

TABLE 23: Manitoba Environments proposed classification of surface waters.

CLASS	CLASS 1 DOMESTIC CONSUMPTION	CLASS 2B COOL WATER AQUATIC LIFE AND WILDLIFE	CLASS 3 INDUSTRIAL CONSUMPTION	CLASS 4A GREENHOUSE IRRIGATION	CLASS 4B FIELD CROP IRRIGATION	CLASS 4D LIVESTOCK WATERING	CLASS 5A PRIMARY RECREATION	CLASS 5B SECONDARY RECREATION
PROTECTION LEVEL		ROUTINE	ROUTINE	ROUTINE	ROUTINE	ROUTINE	ROUTINE	ROUTINE
RED RIVER	YES	YES	YES	YES	YES (3)	YES	YES	YES
ASSINIBOINE RIVER		YES	YES	YES	YES (3)	YES		YES
SEINE RIVER		YES	YES		YES	YES		YES
LA SALLE RIVER	YES	YES	YES		YES	YES		YES
OMAND'S CREEK		YES			YES			YES
STURGEON CREEK		YES			YES	YES		YES
BUNNS CREEK		YES			YES			YES
COOK'S CREEK (1)		YES	YES		YES	YES		YES
METLEY CREEK (2)		YES	YES		YES	YES		YES
DEVILS CREEK		YES	YES		YES	YES		YES
BALDRY CREEK	not classified							
GRASSMERE CREEK	not classified							
BOTTOMLY CREEK	not classified							
TRURO CREEK	not classified							
McLEOD'S CREEK	not classified							
PARKS CREEK	not classified							
GUNNS CREEK	not classified							
MIREY CREEK	not classified							

Note: Proposed classification is based on both existing and potential use.
(1) Includes Dubes Creek
(2) Includes Wavey and Muckle creeks
(3) Fecal coliform objective of 200/100 ml, due to body contact irrigation.

Class 3: Industrial Consumption:

It is proposed that the Red, Assiniboine, Seine and La Salle rivers, along with Cook's Netley and Devils creeks be classified for industrial consumption. Presently, the Red River is the only surface water within the classification area being utilized for industrial consumption. This water is utilized for cooling purposes. Numerical objectives have not been adopted for this class. Rather the unique requirements of industries are considered on a site-specific basis during assessments and licencing of upstream dischargers. Generally, guidelines for industrial water quality, developed by the Canadian Council of Ministers of the Environment (CCME) are used for this purpose (29).

Class 4A: Greenhouse Irrigation:

Application of objectives from this category will provide protection for intensive horticultural crop production, where irrigation is used as the only source of water. These objectives will ensure the long-term protection of soils from the accumulation of substances that may be harmful or cause a reduction in fertility; will ensure the protection of plants; and will ensure the protection of humans from the harmful effects caused by the accumulation of substances on produce that may not be processed prior to consumption. This classification proposes that the Red and Assiniboine Rivers be protected for this use. The other surface waters within the classification area would unlikely be utilized as a sole source of irrigation water for intensive horticultural crop protection.

Class 4B: Field Crop Irrigation:

The objectives for this use class, provide protection for field crop production where irrigation water is used to supplement natural precipitation. These objectives will ensure the long-term protection of soils from the accumulation of substances that may be harmful or cause a reduction in fertility; will ensure the protection of plants; and will ensure the protection of humans from the harmful effects caused by the accumulation of substances on produce that may not be processed prior to consumption. This category may be applicable only during the irrigation season. This use classification would apply to the irrigation of the following:

1. Lawn watering
2. Domestic gardens
3. Commercial fruit and vegetable gardens.
4. Parks and golf courses
5. Cereal crops
6. Horticultural operations

Class 4C: Livestock Watering:

This category defines objectives that will ensure the protection of all classes and ages of livestock and poultry from inhibitory effects following water consumption. It is proposed that all surface waters within the classification area, with the exception of Omand's Creek and Bunn's Creek, be protected for livestock watering. There is currently no knowledge of livestock watering occurring in Omand's and Bunn's Creeks. Considering the location and the size of these two tributaries, it is unlikely that they will be utilized for future livestock watering activities.

Class 5A: Primary Recreation:

The objectives within this classification are intended to protect surface water used for activities in which the entire body may become completely immersed. Such activities include swimming, wading, dabbling, water-skiing and jet-skiing. It is proposed

that only the Red River be classified for primary recreation.

Although the high turbidity of the Red River makes the river at, times, unsuitable for swimming, other activities such as water-skiing and jet-skiing are not impaired by this high turbidity. Since the City of Winnipeg does not permit water-skiing on the Assiniboine River, this proposal does not classify this portion of the Assiniboine River for primary recreation. Due to the lack of organized swimming areas and the shallowness of many of the tributaries, this proposal does not classify any of the tributaries for primary recreation.

Class 5B: Secondary Recreation:

This category defines objectives that will provide protection to waters which are suitable for activities in which water use is incidental, accidental or sensory. Examples of these activities include fishing, boating, camping, picnicking, hunting and hiking. It is proposed that all surface waters within the classification area be protected for secondary recreation activities.

6.0 WATER QUALITY:

The following section will detail water quality conditions in the Red and Assiniboine rivers, and in those tributaries for which there is data.

Both the data collected by the City of Winnipeg and Manitoba Environment was used for these analyses. As a result of the differences in the variables monitored and the period of record, specific data sets were selected to perform different statistical procedures. Table 24 provides a complete list of data sources used for the water quality assessments.

The scientific literature varies on the methods of dealing with detection limit values. One common approach, which was adopted in this study, is to assign the detection limit to all non-detected values. It is recognized that this results in a biased overestimate of the mean and a biased underestimate of the standard deviation.

In order to facilitate the readability of this document, the majority of tables and graphs describing water quality have been placed in the accompanying Appendix. An "A" precedes all figures and table numbers which have been placed in the Appendix.

The water quality of the Red and Assiniboine Rivers is discussed together (Section 6.1) with a subsequent section dealing with the water quality in the tributaries (Section 6.2). For each figure, for each sampling station, the existing or potential water uses and their corresponding water quality objectives are illustrated on the graph. This information is further summarized in tabular form, illustrating the monthly and yearly percent exceedence of the Manitoba Surface Water Quality Objectives. In all cases, the exceedences of the Manitoba Surface Water Quality Objectives are based on the proposed use classification (Table 23).

A separate table for each variable illustrates the existence of increasing or decreasing trends in the data. Student "t" paired difference tests were conducted on Manitoba Environment data collected from the Assiniboine River at Headingley, the Red River at the South Floodway and at the Selkirk Bridge. This test indicates whether there is any statistically significant difference in the water quality between these three stations located upstream and downstream of Winnipeg. The results of these paired "t" tests are illustrated for each variable.

6.1 RED AND ASSINIBOINE RIVERS:

6.1.1 BACTERIOLOGICAL PARAMETERS: FECAL COLIFORM:

Fecal coliforms are useful indicators because they are present in virtually all warm-blooded animals including humans, in numbers far exceeding the pathogens. Testing for every possible pathogen on a routine basis is impractical from both a financial and time perspective. As a result, it is common to test for only the more plentiful, non-pathogenic bacteria present in animal and human feces. Elevated numbers of these organisms are indicative of fecal contamination and the possible presence of such pathogens as *Psuedomonas aeuroginosa, Salmonella,* .

TABLE 24: Description of data base used for water quality assessment.

SURFACE WATER	SITE #	LOCATION	FREQUENCY OF SAMPLING	MAX. PERIOD OF RECORD(1)	MAX. # VARIABLES SAMPLED	COLLECTION AGENCY
Assiniboine R.	WQ18	Headingley	Monthly	1978-89(2)	55	Man. Env.
Assiniboine R.	WQ451	Headingley	Biweekly	1978-89	14	City of Wpg.
Assiniboine R.	WQ452	West perimeter	Biweekly	1978-89	7	City of Wpg.
Assiniboine R.	WQ453	Main St. Bridge	Biweekly	1977-89	14	City of Wpg.
Red R.	WQ367	South gate of Floodway	Monthly	1978-89(2)	59	Man. Env.
Red R.	WQ445	Floodway Control	Biweekly	1978-89	14	City of Wpg.
Red R.	WQ576	Fort Gary Bridge	Biweekly	1982-89	11	City of Wpg.
Red R.	WQ447	Norwood Bridge	Biweekly	1978-89	7	City of Wpg.
Red R.	WQ448	Redwood Bridge	Biweekly	1978-89	6	City of Wpg
Red R.	WQ449	North Perimeter	Biweekly	1978-89	14	City of Wpg.
Red R.	WQ450	Lockport Bridge	Biweekly	1978-89	14	City of Wpg.
Red R.	WQ142	Selkirk Bridge	Monthly	1965-89(2)	59	Man. Env.
Seine R.	T1	Highway # 59.	Summer-monthly	1978-89	11	City of Wpg.
Seine R.	T2	Provencher	Summer-monthly	1978-89	11	City of Wpg.
Sturgeon Cr.	T3	Perimeter Hwy.	Summer-monthly	1978-89	11	City of Wpg.
Sturgeon Cr.	T4	Portage Ave.	Summer-monthly	1978-89	11	City of Wpg.
Omand's Creek	T5	Portage Ave.	Summer-monthly	1978-89	11	City of Wpg.
La Salle R.	T6	Highway # 75.	Summer-monthly	1978-89	11	City of Wpg.
Bunn's Cr.	T7	Henderson Hwy.	Summer-monthly	1978-89	11	City of Wpg.

(1) The following portions of the data set were used for the specific water quality assessment:
1. Trend analysis - entire period of record
2. Graphic display - 1980-89.
3. Exceedence statistics - 1980-89.
4. Paired T tests - 1980-89.

(2) Limited sampling frequency in 1984 and 1985.

Shigella, *Vibrio* and *Clostridium* (29). Unfortunately theratio of fecal coliform to viruses can vary significantly.

The potential exists for the transmission of disease vectors through contact with contaminated water. The most common ailments are infections of the eyes, ears, nose, throat and skin, as well as gastroenteritis (fever, stomach cramps, vomiting and diarrhea). Enteric viruses, such as strains of polioviruses have been isolated from Red River surface water as well as drinking water samples, indicating that some viruses survived both the sewage and water treatment processes (42).

Epidemiological studies have attempted to correlate the density of indicator organisms with a predictable rate of gastroenteritis amongst bathers. The epidemiological research conducted by Dufour (43) and Cabelli (44) found relationships between bather related gastroenteritis and the indicator organisms fecal coliform, *Escherichia coli* and enterococci. A Canadian epidemiological study, conducted by Seyfried in 1987, demonstrated a relationship between bather-related gastroenteritis and fecal coliform organisms but not with enterococci (45). The results of these epidemiological studies have been utilized in Canada and the United States to set water quality objectives in recreational waters. A third epidemiological study conducted in France has also identified the existence of a relationship between fecal coliform densities and morbidity (46).

Through the process of Clean Environment Commission hearings, the Manitoba Surface Water Quality Objectives have been reviewed and adopted to provide protection to Manitoba's surface waters. Manitoba has adopted fecal coliform objectives for surface waters used for recreation and irrigation (3). For primary recreation activities, the objective is 200 organisms/100 mL. For secondary recreation, and irrigation of produce which may not be washed prior to consumption, the objective is 1000 organisms/100 mL. Should human contact with the irrigation water be probable, a fecal coliform density of 200/100 mL should apply.

The Canadian Water Quality Guidelines recommend that the geometric mean of at least five samples, taken during a period not to exceed 30 days, should not exceed 200 fecal coliform/100 mL. In addition, these Federal/Provincial guidelines recommend a maximum fecal coliform density of 100/100 mL in irrigation water used on produce which may not be washed prior to consumption (29). The Manitoba objectives are consistent with the federal guidelines for primary recreation, although the provincial objectives are less restrictive for irrigation use.

Figures A1 to A4 illustrate the fecal coliform data for the sampling stations along the Assiniboine River. Fecal coliform data from the Red River sampling stations is compiled in Figures A5 to A12. Tables A1 to A18 summarize the exceedence of the recreation and irrigation objectives.

On average, between 1980 to 1989, exceedence of the 200 fecal coliform/100 mL objective is low at both the floodway control sampling location (3.2%) and at the Headingley sampling location (7.5%). Exceedences increase significantly downstream of these locations. At sampling locations on the Red River between the Fort Gary Bridge and Lockport, primary recreation objectives are exceeded 57% to 96% of the time. At Selkirk, the exceedence rate of the 200 fecal coliform objective is 65% (Figure A12). Within the Assiniboine River, the objective is exceeded 44% of the time at the west perimeter (Table A3) and 86% of the time at the Main Street Bridge (Table A5). Monthly exceedence data

suggest that exceedence levels are highest in the winter months, although summer month exceedences are generally very high.

The secondary recreation and irrigation fecal coliform objective is 1000 fecal coliform/100 mL. Tables A2 and A8 indicate that exceedences are low at Headingley (2%) and at the South Floodway control (1%). Downstream of these stations, exceedences within the months of May to October range from 0% to 91%. Exceedences are highest at the North Perimeter location, downstream of the NEWPCC (Table A16). Fecal coliform densities as high as 285,000/100 mL have been recorded at this site in August. At Selkirk the exceedence rate is 33% (Figure A12).

Figures 6 and 7 summarize the exceedence frequency of the fecal coliform objectives of 200/100 mL and 1000/100 mL in the Red and Assiniboine rivers.

As a minimal level of treatment, all surface waters used for domestic consumption should be disinfected. Prior to consumption, treated domestic water should always contain less than 10 organisms/100 mL (3). This level can be achieved by disinfection of the raw water source. However, in an event of a water treatment plant malfunction, the microbiological quality of the Red River water would be unsuitable for human consumption.

Figure 8 illustrates the extent of microbial water quality degradation in the Red River between the upstream sampling station at the South Floodway, and the downstream station at the North Perimeter.

A paired t-test analysis shows that fecal coliform levels at Selkirk are statistically higher (mean difference of approximately 5000/100 mL) than that found at Headingley or at the South Floodway control site (Table A19). Trend analysis indicates that only the Fort Gary Bridge sampling station demonstrates a significant increasing trend (Table A19), suggesting that little detectable improvement or deterioration has occurred with respect to fecal coliform levels in the Red and Assiniboine Rivers in the last 10 years.

6.1.2 PHYSICAL PARAMETERS

TURBIDITY:

Turbidity is a description of the optical properties that cause light to be absorbed and scattered rather than transmitted in straight lines. The level of turbidity is dependent upon the amount of suspended matter such as silt, clay, fine organic matter, plankton and other microscopic organisms.

Manitoba Surface Water Quality Objectives have been developed for turbidity levels for primary recreational use. The rationale for this objective is based on the need for water clarity for situations where swimmers are in distress. Lifeguards and other people should be able to identify people in need of help, and swimmers should be able to see while swimming underwater. For this reason, swimming in the Red and Assiniboine rivers when turbidity levels exceed 50 NTU is not recommended. Turbidity levels have little impact on other primary recreational activities such as water-skiing, jet-skiing, knee-boarding and tubing.

Turbidity data has been collected along the Assiniboine and Red rivers (Figures A13 to A20). Within the Red River, turbidity levels decrease downstream of the South Floodway control station with levels at Lockport being approximately half of those recorded upstream of Winnipeg (Tables A20 to A22). Within this stretch of the Red River, the exceedence frequency ranges from 14%-76% between June and August.

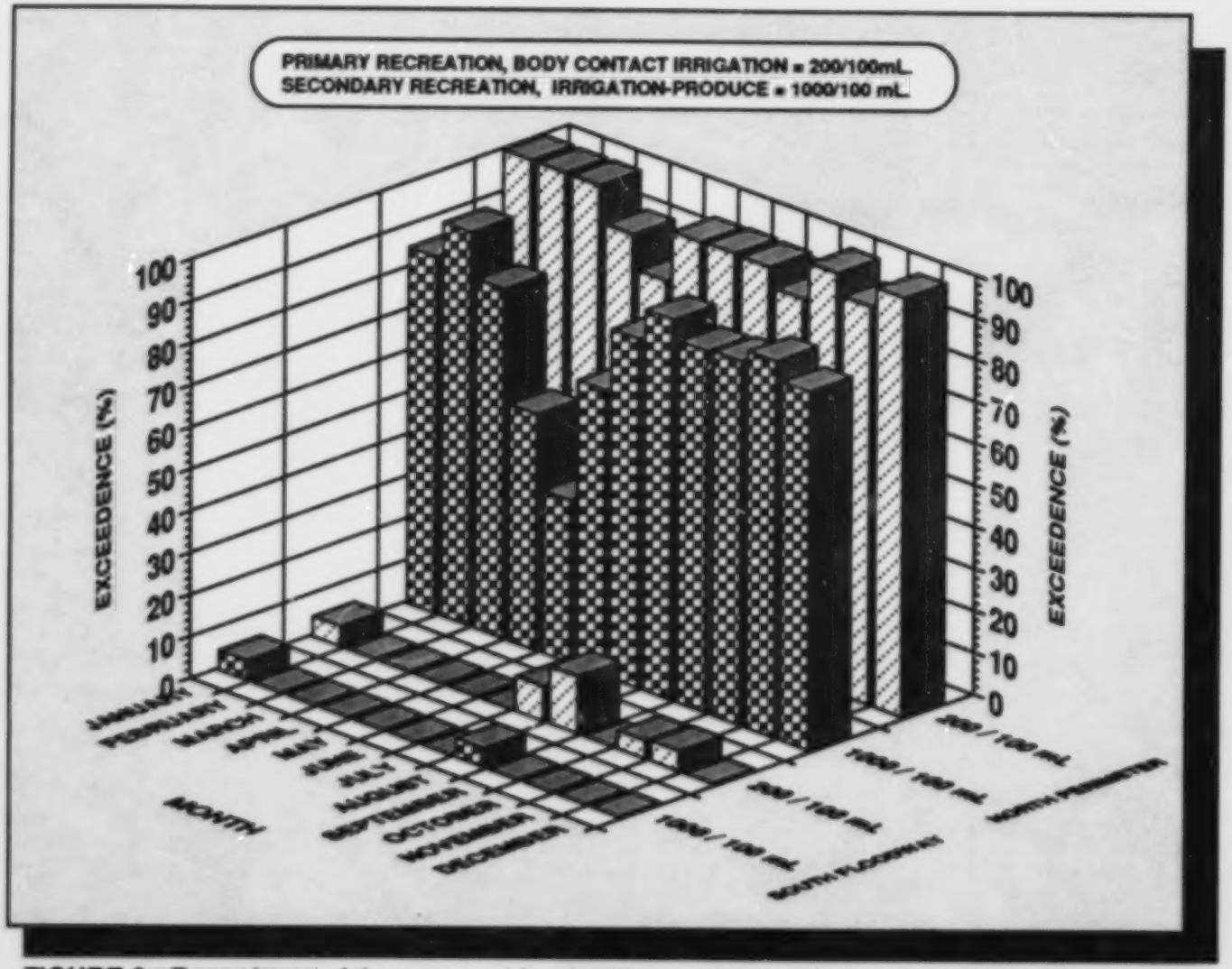


FIGURE 6: Exceedence of the proposed fecal coliform objectives for the Red River, upstream and downstream of Winnipeg (1980-89).

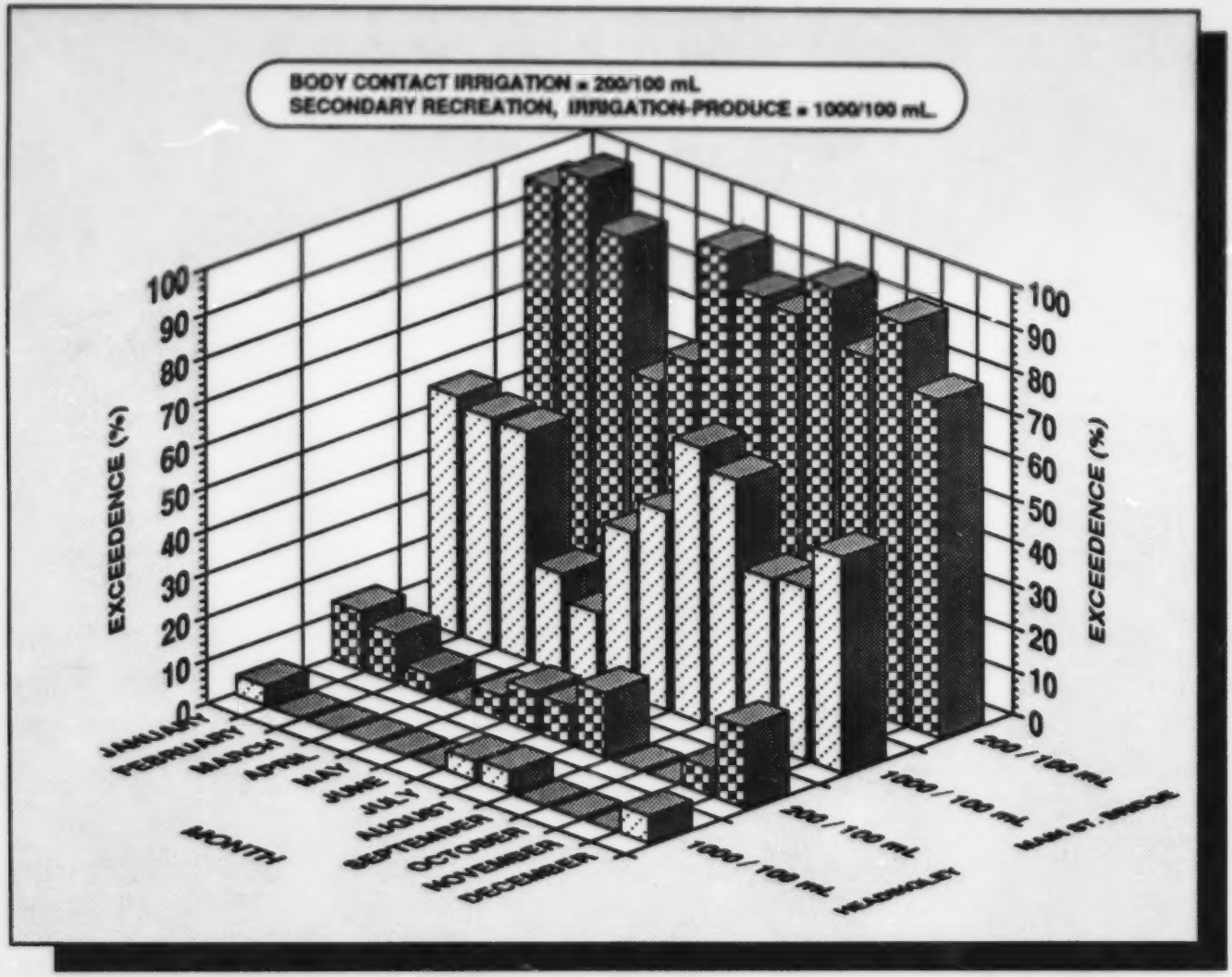


FIGURE 7: Exceedence of the proposed fecal coliform objectives for the Assiniboine River, upstream and downstream in Winnipeg (1980-89).

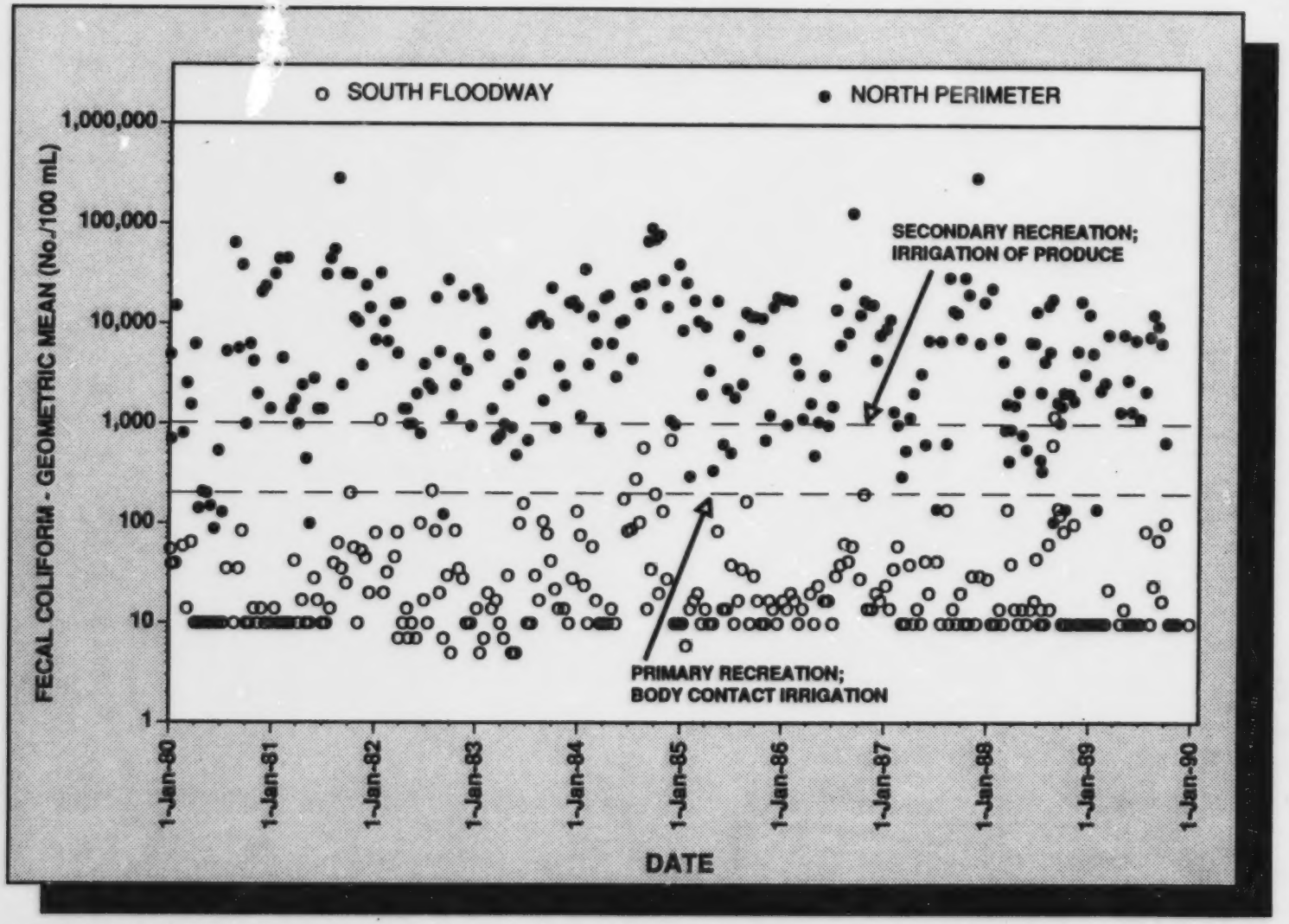


FIGURE 8: Fecal coliform concentrations upstream (South Floodway) and downstream (North Perimeter) of Winnipeg.

A paired t-test comparing turbidity levels at South Floodway versus those recorded at Selkirk, indicates that turbidity levels are significantly lower at Selkirk (Table A23). Trend analyses did not demonstrate any significant increasing or decreasing turbidity trends at any of the sites on the Red or Assiniboine rivers (Table A23).

Turbidity levels are highest during April and lowest during the winter months. Figure 9 illustrates changes in turbidity as it relates to monthly average Lockport flow data. With the decreased flow in June, a divergence in the turbidity levels between the South Floodway site and the more downstream sites is observed. It appears that the Lockport Dam which holds back Red River water between June and September, creates a sequential decrease in the turbidity upstream of the dam. The reduced velocity in the impounded water results in less energy to keep particles in suspension. Therefore summer and fall turbidity levels are progressively lower from south to north on the Red River.

TOTAL SOLIDS:

In the Red and Assiniboine rivers, levels of total solids, which comprise both dissolved and suspended material, generally range between 400 to 1000 mg/L (Figures A21 to A28). There are no Manitoba Surface Water Quality Objectives established for total solids in surface waters.

Two sites along the Assiniboine River indicate significant decreasing trends in total solids, whereas one significant increasing trend was detected upstream of the the City of Winnipeg on the Red River (Table A24).

TOTAL SUSPENDED SOLIDS:

Manitoba Surface Water Quality Objectives have been established for concentrations of total suspended solids (TSS) due to their potential impact on aquatic life. High levels of suspended solids will obstruct light and therefore may reduce primary productivity. Suspended solids can also act as a reservoir for toxicants. The direct effect of TSS on fish appears to vary depending on the exposure period, the concentration and the fish species.

The TSS objective for the protection of aquatic life and wildlife has been set at 25 mg/L. Figures A29 to A36 illustrate the TSS data collected at sites along the Red and Assiniboine Rivers. At sites along the Assiniboine River, TSS Manitoba Surface Water Quality Objectives are exceeded approximately 80% of the time (Tables A25 and A26). Exceedence of this objective is somewhat lower within the Red River (Tables A27 to A30), however, exceedence frequencies are very high at all sampling locations during the summer months. The Headingley sampling station has a significantly higher load of TSS, as compared to the Selkirk location, however there are no significant increasing trends in TSS at any of the sampling locations (Table A30).

The majority of suspended solids in the Red and Assiniboine are soil particles derived from soil erosion and scouring of the riverbed during periods of high flow.

TOTAL DISSOLVED SOLIDS:

Total dissolved solids (TDS) is defined as material that passes through a standard glass fibre filter and remains after evaporation and drying to a constant

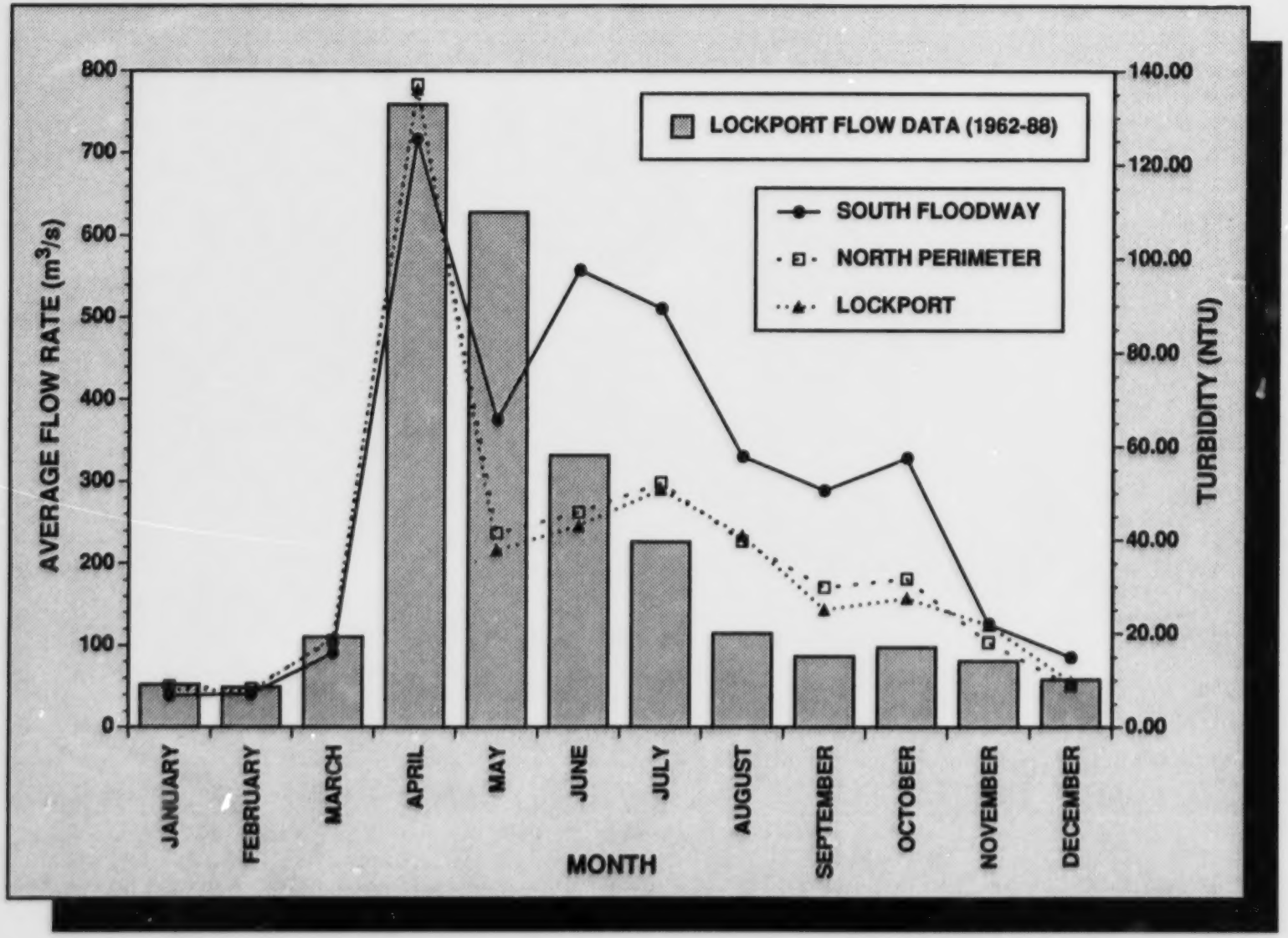


FIGURE 9: Monthly average turbidity levels at sampling locations along the Red River (1980-1989).

weight. TDS refers to the total concentration of dissolved matter in water. The principal anions include carbonate, bicarbonates, chlorides, sulphates, phosphates and nitrates. The major cations include calcium, magnesium, sodium, potassium and iron. The composition and concentration of TDS influence the density and diversity of both aquatic plants and animals.

Manitoba Surface Water Quality Objectives for TDS differ within the agricultural classification. An objective level of 700 mg/L has been set for water used for greenhouse irrigation purposes. Plants vary in their tolerance to salinity of irrigation waters. In general, fruit crops are most sensitive, followed by vegetables, field and forage crops (29).

The concentration range of TDS levels within the Red and the Assiniboine is illustrated in Figures A37 to A39. These figures show that the Manitoba Surface Water Quality Objectives for greenhouse irrigation purposes are exceeded between 9-14% of the time, both upstream and downstream of the City of Winnipeg. For water used for livestock watering, an objective of 3000 mg/L is recommended (3). TDS in the Red and Assiniboine rivers are well below this recommended objective.

Table A31 presents the trend analyses results for the three stations that are presently being monitored for TDS. Between 1985 to 1989, TDS on the Assiniboine River upstream of Winnipeg, have shown a significant decreasing trend, whereas upstream of Winnipeg on the Red River, the data indicate a significant increasing trend. There is no significant difference in the concentration of TDS between these three sites (Table A31).

TRUE COLOUR:

True colour measurements have been monitored at three sampling locations (Figures A40 to A42). The colour was found to be significantly higher at the South Floodway sampling site as compared to the Headingley location, although no significant trends were found at the Headingley, Selkirk or South Floodway sites (Table A32).

TEMPERATURE:

Temperature data, evaluated for increasing or decreasing trends, showed no significant change at any of the sampling stations (Table A33). Results of a paired t-test suggest that the water temperature at Selkirk is significantly higher than that recorded at the South Floodway site, although the mean difference amounts to only 0.43 °C.

The discharge of warm water may be undesirable, since warm water decreases the amount of dissolved oxygen available for aquatic life. This is because warm water cannot hold as much oxygen as colder water. In addition, the discharge of warm water can send false environmental cues to aquatic organisms. This could lead to inappropriate spawning or migration behavior for that time of the year.

CONDUCTIVITY:

Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. Water having high conductivity is undesirable for irrigation use as it will reduce the availability of water for plant growth. Manitoba Surface Water Quality

Objectives for conductivity levels have been established to protect agricultural water uses. Figures A43 to A45 illustrate the degree of compliance with these established objectives. Conductivity levels at these three sampling stations exceed greenhouse irrigation objectives 14 to 19% of the time, although most of these exceedences occur between December and January. Upstream of Winnipeg at the South Floodway site, the field crop objective (1500 µS/cm) is exceeded at a rate of 7%. No values over the 1500 µS/cm have been recorded at Headingley or Selkirk.

The conductivity levels in both the Red and Assiniboine rivers are suitable for livestock watering (*i.e.* less than 4300 $\mu S/cm^2$)

The data indicate that conductivity levels are increasing both at Selkirk and at the South Floodway site, although no similar trend was observed on the Assiniboine River at Headingley. There is no significant difference in the conductivity among these three sampling stations (Table A34).

6.1.3 NUTRIENTS

Nutrient enrichment and eutrophication have been accelerated by human activity. The impacts of nutrient enrichment can result in changes in the species composition within an aquatic system. For example, under high phosphorus and limiting nitrogen conditions, the algal community can shift towards a less desirable nitrogen fixing blue-green algal assemblage. An increase in algal biomass can lead to an increased rate of decomposition of this organic material, which can deplete dissolved oxygen sources under extreme conditions. Changes in the density and diversity of invertebrates and fish usually accompany significant changes in the eutrophic status.

6.1.3.1. NITROGEN:

NITROGEN CYCLING:

Assimilation of ammonia and nitrate by aquatic plants and bacteria results in the formation of organic nitrogen. Ammonification carried out by bacteria and fungi, is the breakdown of organic nitrogen to ammonia. Nitrification, the microbial oxidation of ammonia to nitrate and nitrite, is mediated by aerobic bacteria. Denitrification is an anaerobic process by which nitrate is transformed to nitrite, nitrous oxide and molecular nitrogen. Biological nitrogen fixation converts molecular nitrogen to ammonia. Many blue-green algae and bacteria are capable of nitrogen fixation. The rates of these nitrogen transformations in the Red and Assiniboine rivers is unknown.

AMMONIA:

Excessive quantities of ammonia are undesirable in aquatic systems for two reasons:

1. Ammonia is readily bioavailable as a nutrient source, and may therefore significantly contribute to increased aquatic weed and algal growth.

2. The un-ionized form of ammonia is toxic to aquatic invertebrates and fish.

Ammonia objectives have been established for the protection of aquatic life. The toxicity of aqueous ammonia has been primarily attributed to the un-ionized form. Acute toxic responses of fish to un-ionized ammonia include loss of equilibrium, hyperexcitability, increased breathing, cardiac output and oxygen uptake, convulsions, coma and death. Chronic responses include a reduction in hatching success, reduction in

growth rate and morphological development, and pathological changes in the tissues of gills, liver and kidneys (41). The acute toxicity of ammonia increases as dissolved oxygen, pH and temperature decrease. The un-ionized ammonia objective, which is calculated on the basis of temperature and pH, was developed specifically for the protection of Manitoba's fish species (41).

Figures A46 to A48 and Figures A49 to A54 illustrate the ammonia and un-ionized ammonia concentrations at sites along the Assiniboine River and Red River, respectively. Calculated exceedences are illustrated on these figures as open boxes.

Monthly and yearly variations in un-ionized ammonia concentrations are summarized in Tables A35 to A40. Exceedences at Headingley and the South Floodway control average 6 to 7%. Downstream of these sites to Lockport, average exceedences range from 7 to 29%, although monthly exceedences range as high as 59% (Table A39). At Selkirk, the un-ionized ammonia objective has been exceeded 44% of the period of record between 1985 to 1990 (Figure 54).

Figures 10 and 11 summarize the monthly exceedence of the un-ionized ammonia objective in the Red and the Assiniboine rivers.

Paired t-test results indicate that both ammonia and un-ionized ammonia concentrations are statistically higher at Selkirk than at Headingley or the South Floodway control site (Table A41). Trend analysis indicates that ammonia levels are increasing along the Red River downstream of the floodway control location Table A41). This trend is not apparent at sites along the Assiniboine River, nor upstream of the discharge site for the SEWPCC on the Red River. It is worthy to note that the increasing trend of ammonia and un-ionized ammonia within the City of Winnipeg was significant despite the lowering of the City of Winnipeg lab detection limit in 1988 from 0.2 mg/L to 0.02 mg/L.

Figure 12 illustrates the concentration of ammonia in the Red River as it relates to the month of the year as well as the distance from the headwater site at the South Floodway. This figure emphasizes the degree to which waste-water discharge from within Winnipeg increases the ammonia load in the Red River. As expected, the highest concentrations of ammonia are found during the months of lower flow rates. Walleye are exposed to these higher ammonia levels during their annual migration in September and October.

TOTAL KJELDHAL NITROGEN:

Total Kjeldhal nitrogen (TKN) measurements include both ammonia and organic nitrogen constituents, but do not account for nitrate/nitrite concentrations. TKN levels along the Assiniboine River and the Red River are illustrated in Figures A55 to A57 and Figures A58 to A63 respectively.

Manitoba Surface Water Quality Objectives have not been developed for TKN concentrations in surface waters, therefore exceedence tables for this variable are not given.

The paired t-test results indicate that the levels of TKN are significantly higher at the Selkirk sampling station, as compared to both the Headingley and South Floodway control site (Table A42). This statistical test also demonstrates that TKN levels are significantly higher in the Red River at the South Floodway site compared to those found in the Assiniboine River at Headingley. Trend analysis suggests a significant increase in TKN levels in the Red River within and downstream of the City of Winnipeg (Table A42). Figure 13 illustrates the increase in TKN concentrations in the

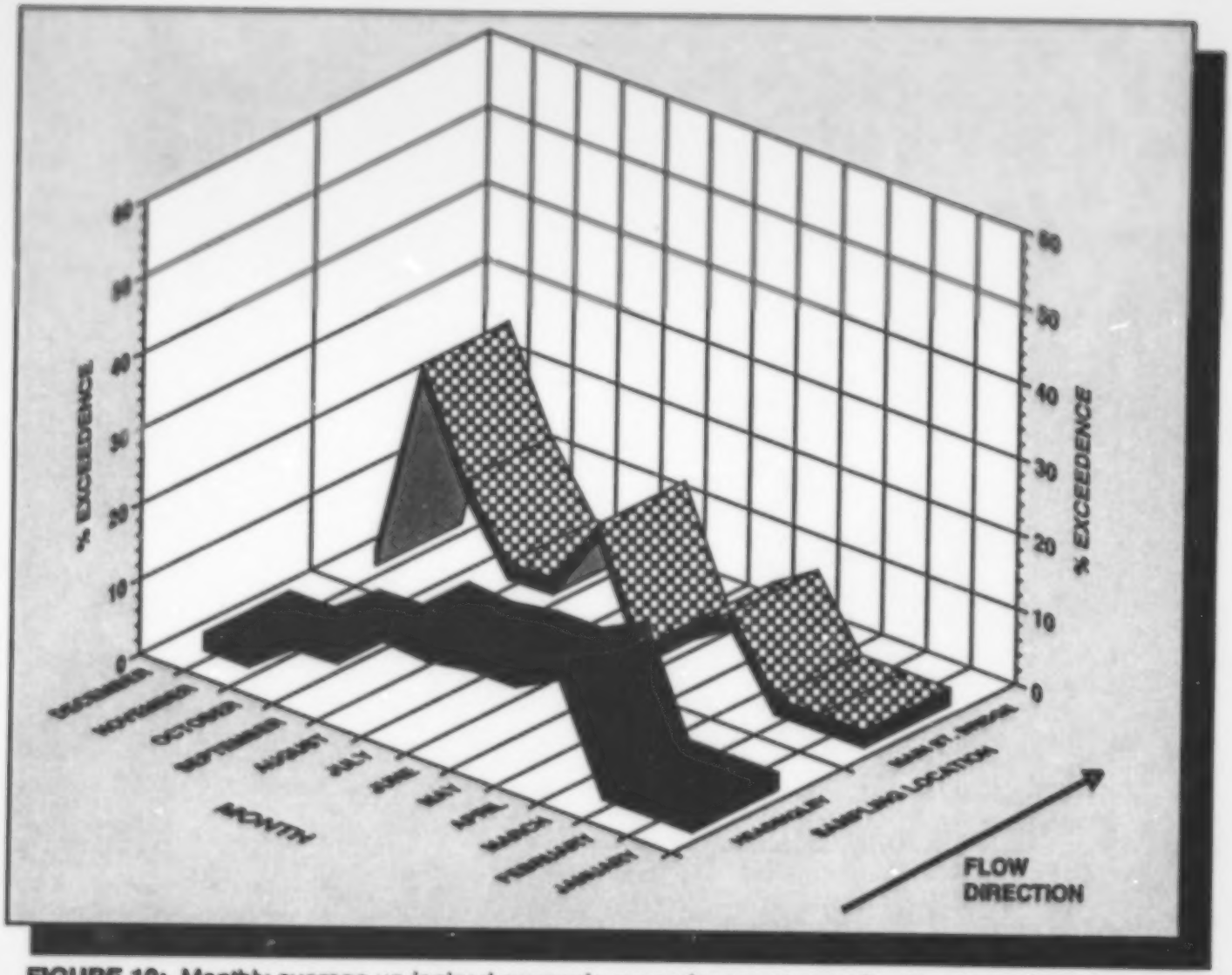


FIGURE 10: Monthly average un-ionized ammonia exceedences at sampling locations along the Assiniboine River (1980-89).

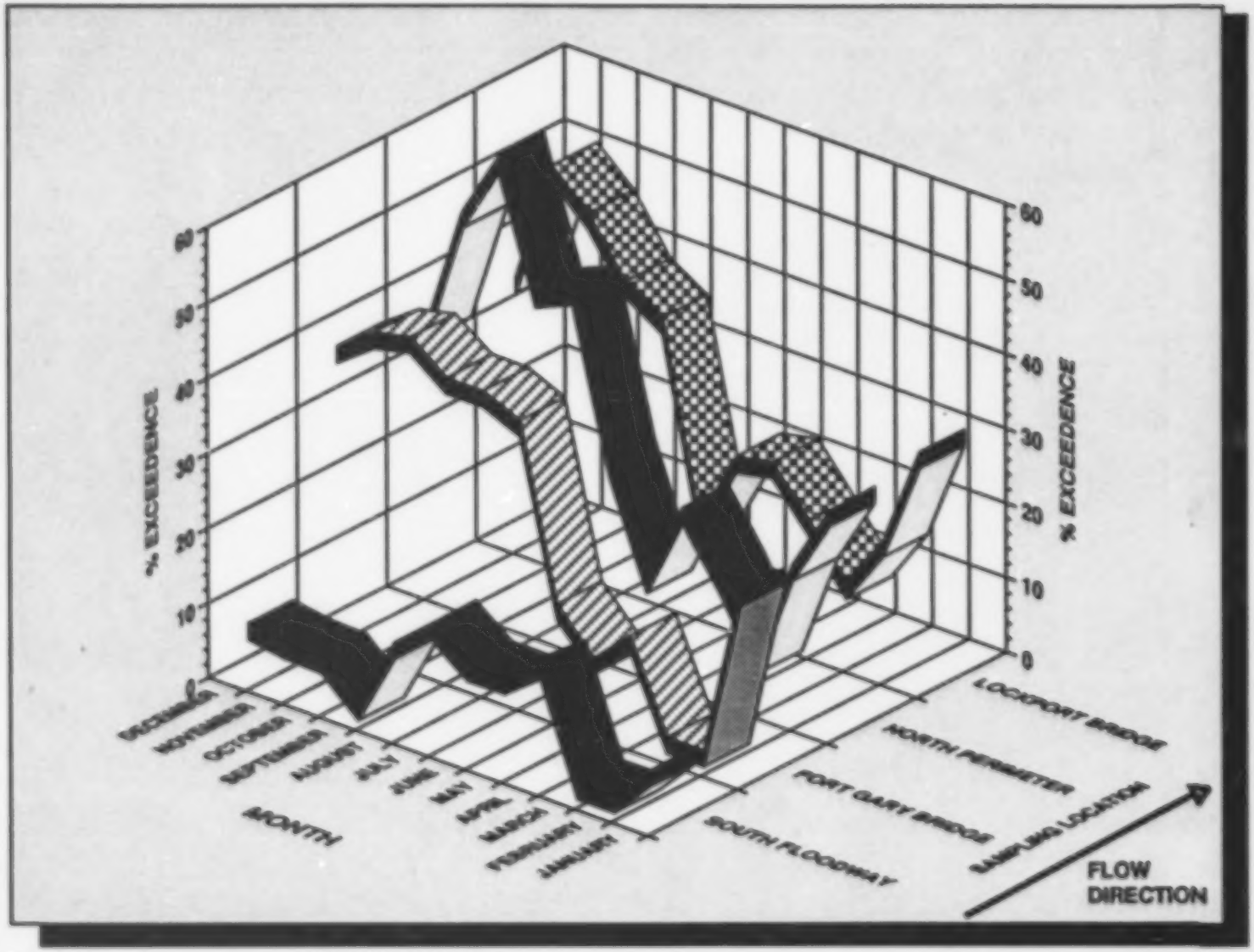


FIGURE 11: Monthly average un-ionized ammonia exceedences at sampling locations along the Red River (1980-89).

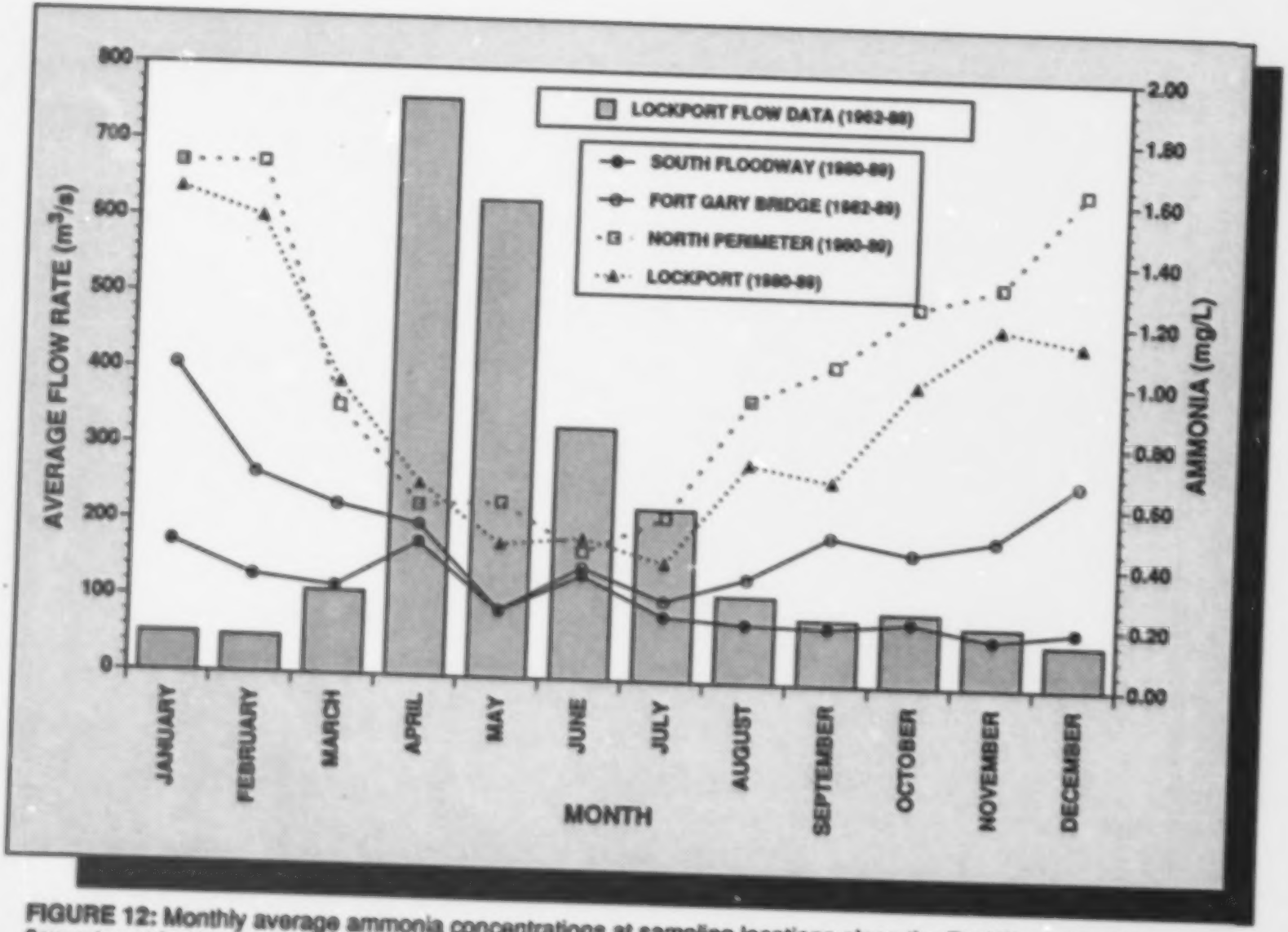


FIGURE 12: Monthly average ammonia concentrations at sampling locations along the Red River. Monthly average flow rates at Lockport are also illustrated.

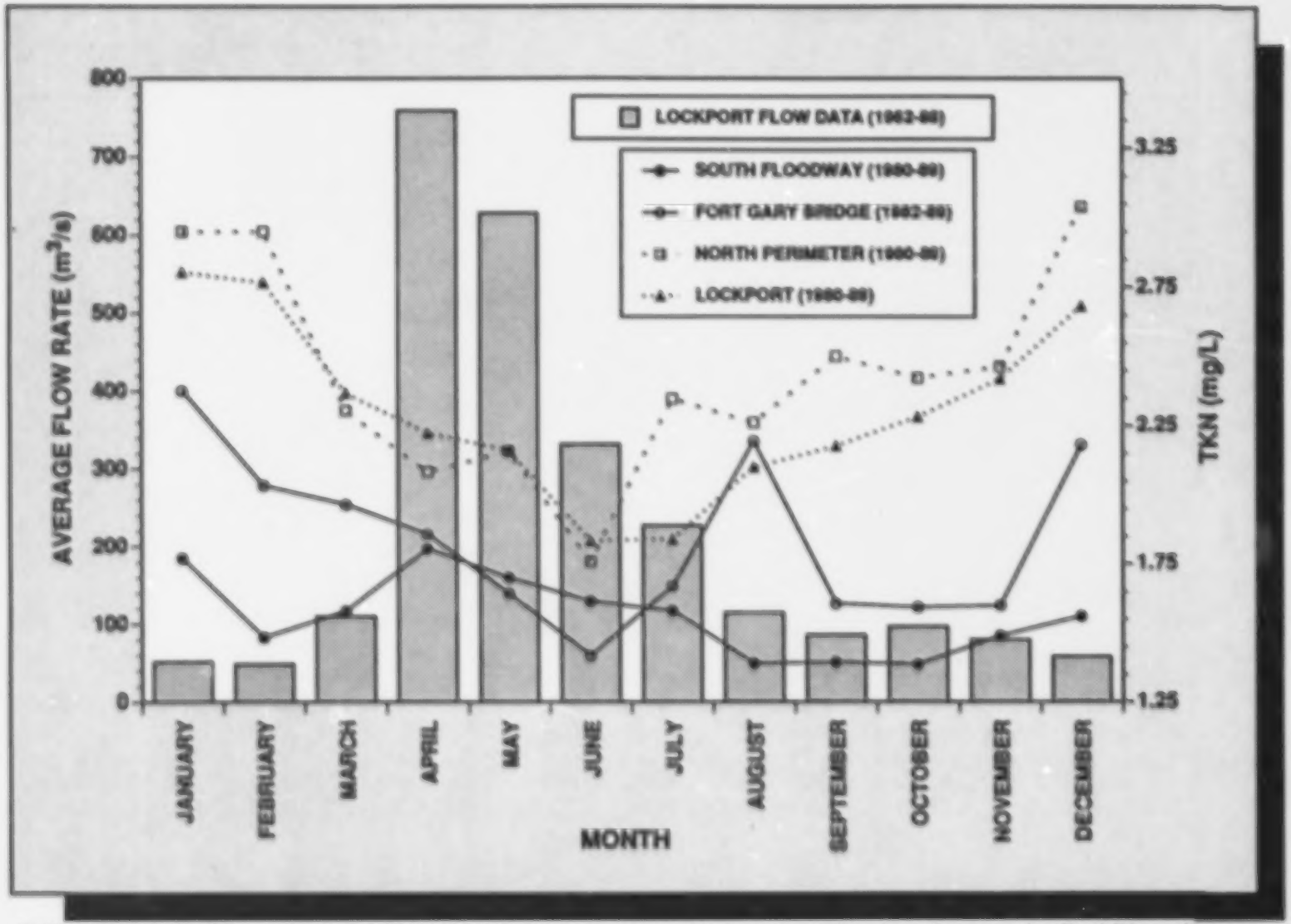


FIGURE 13: Monthly average total kjeldhal nitrogen concentrations at sampling locations on the Red River. Monthly average flow rates at Lockport are also illustrated.

Red River between upstream and downstream sampling locations.

NITRATE AND NITRITE:

Soil leaching in areas where inorganic nitrate fertilizers are used, can significantly increase the nitrate concentration in river water. Municipal and industrial wastewater can also contribute to anthropogenic point source loading. Manitoba recommends a maximum nitrate/nitrite concentration of 10 mg/L in surface waters used for domestic consumption and livestock watering (3).

Dissolved nitrate-nitrite concentrations are shown in Figures A54 to A72. There have been no samples which exceed the 10 mg/L objective. Concentrations range from detection limits up to 4.0 mg/L.

Statistically higher levels are found at the Selkirk site compared to those levels in Headingley or at the floodway control site (Table A43). Concentrations are higher upstream of the City of Winnipeg in the Red River, compared to levels upstream of the City of Winnipeg in the Assiniboine River (Table A43). Trend analysis indicates that levels of nitrate/nitrite are generally remaining stable, with a significant decreasing trend only being apparent at the Main Street bridge site on the Assiniboine River (Table A43).

Figure 14 illustrates monthly average nitrate and nitrite concentrations at four locations along the Red River. From this figure it is evident that there is little additional input of nitrate and nitrite from urban discharge. The principal forms of nitrogen in effluent discharge are ammonia and organic nitrogen. Interestingly, nitrate and nitrite levels are high in March which is prior to the period of peak flow (Figure 14). It would appear that during periods of early low flow, runoff water is carrying high concentrations of highly soluble nitrate and nitrite.

6.1.3.2 PHOSPHORUS:

Phosphorus is generally the limiting nutrient to aquatic macrophyte and algal growth. Manitoba Surface Water Quality Objectives have been established for phosphorus not because of direct toxicity, but rather due to the indirect impact of high phosphorus concentrations. High levels of phosphorus often result in excessive growth of aquatic plants and algae which reduces the aesthetic value of surface water. A reduction in oxygen levels with the decomposition of the plant material, can in turn place stress on the aquatic life in the stream. During periods of high flow, algal growth in the Red and Assiniboine rivers is probably limited by light penetration, not by nutrients.

For general guidance, the Manitoba Surface Water Quality Objectives recommend a phosphorus concentration in streams of less than 0.05 mg/L, unless it can be demonstrated that total phosphorus is not a limiting factor (3). Total phosphorus levels at sites along the Assiniboine River and Red River are illustrated in Figures A73 to A75 and Figures A76 to A81, respectively. Levels of phosphorus at Headingley average 0.245 mg/L between 1980 to 1989, and 0.313 mg/L downstream at the Main Street Bridge (Tables A44 and A45).

Figures A73, A76 and A71 illustrate dissolved and particulate phosphorus concentrations in addition to total phosphorus. At Headingley, dissolved phosphorus contributes, on average, 40% of the total phosphorus. In the Red River at the SouthFloodway and Selkirk, dissolved phosphorus contributes 60% and 63% of the total phosphorus respectively.

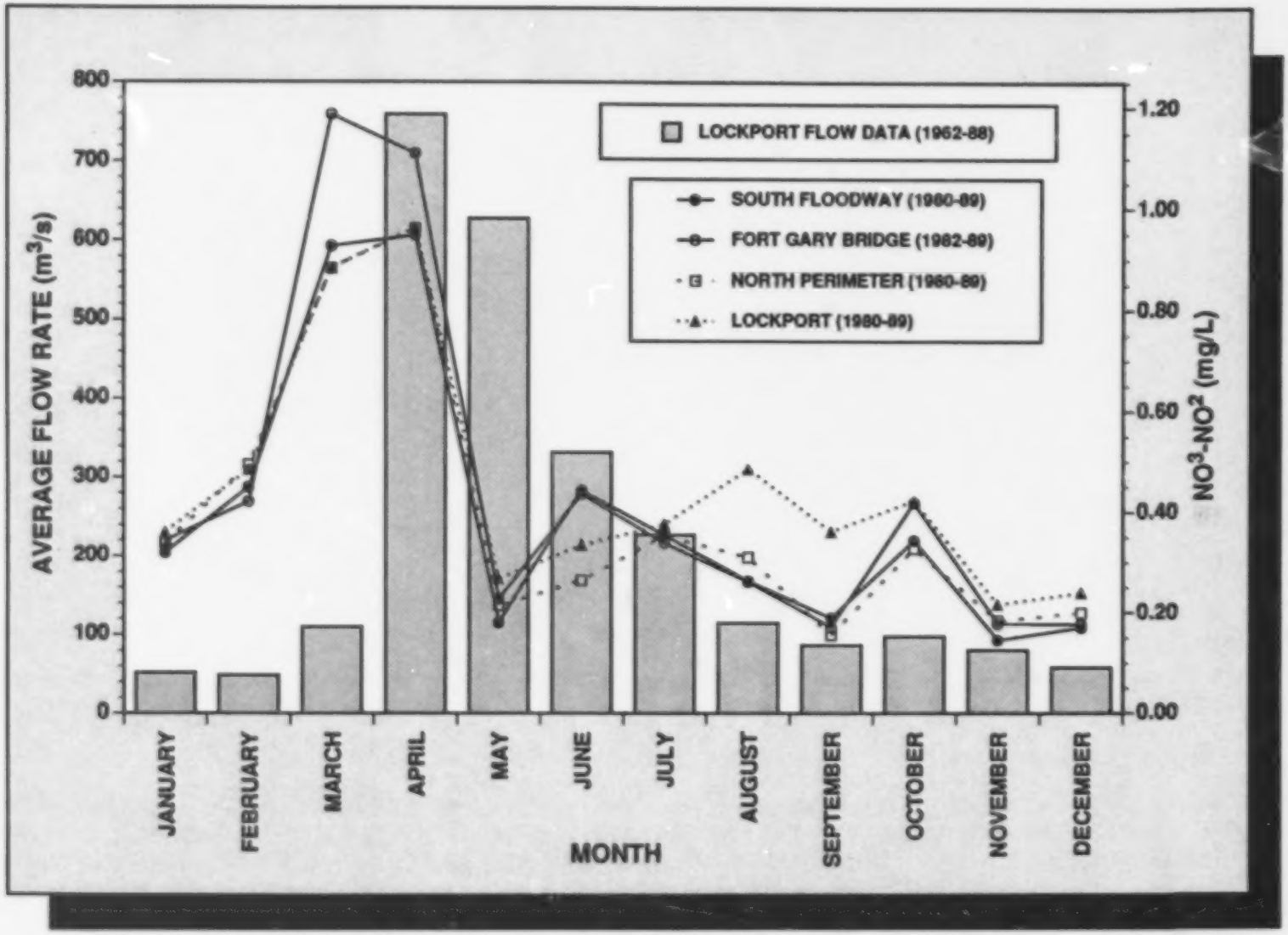


FIGURE 14: Monthly average nitrate-nitrite concentrations at sampling locations on the Red River. Monthly average flow rates at Lockport are also illustrated.

Tables A46 to A49 summarize the phosphorus levels at sampling stations along the Red River. Upstream of the City of Winnipeg at the floodway control, phosphorus levels average 0.270 mg/L. The highest 1980 to 1989 average phosphorus levels (0.335 mg/L), are found at the North Perimeter sampling station (Table 49). In 1989, the mean annual concentration at this location was found to be 0.407 mg/L. On average, 30% more phosphorus leaves Winnipeg via the Red than arrives.

Exceedence of the Manitoba Surface Water Quality Objectives occurs over 99% of the time upstream, within and downstream of the City of Winnipeg.

Total phosphorus levels are statistically higher at Selkirk as compared to Headingley or the floodway control sampling locations (Table A50).

Figure 15 overlays the Lockport flow rate with monthly averages of phosphorus at four sampling locations on the Red River. By evaluating this data on a seasonal trend, it can be seen that maximum phosphorus levels occur during the period of peak runoff. Since phosphorus has a relatively low solubility, it is suspected that initially, the majority of phosphorus enters the river bound up in particulate material. The scouring of the river bed during periods of high flow, contributes to the phosphorus levels through the resuspension of sediments. During April and May there is little difference between the four sampling stations, suggesting that the majority of the loading at this time, is coming either from non-point sources or from scouring. Between August and February the difference is accentuated considerably, indicating point source discharges within the city of Winnipeg (Figure 15).

Trend analysis indicates that phosphorus concentrations are increasing significantly only at the Fort Gary Bridge sampling location (Table A50). All other locations show no significant increasing or decreasing trend.

NUTRIENT IMPACT:

Very little research has been done on the effects of nitrogen and phosphorus loading in the South Basin of Lake Winnipeg. A report prepared by G. Brunskill of the Fresh Water Institute in Winnipeg in 1974, addressed some of the impacts of nutrient loading to Lake Winnipeg (47). This study concluded that the Red River which contributes about 6% of the total water received by Lake Winnipeg, contributes 59% of the total phosphorus and 33% of the total nitrogen annual mass of nutrients added to Lake Winnipeg. Of the total Red River annual load of nutrients to the lake, Winnipeg, was estimated to contribute 33% of the total phosphorus and 26% of the total nitrogen.

Although the large size of the lake increases its assimilative capacity, more than 80% of the phosphorus and over 60% of the nitrogen is added to the smaller, shallow South Basin of Lake Winnipeg (47). The rates of supply of nitrogen and phosphorus fall within the "very eutrophic" range of Vollenweider's lake classification (48). By morphometric, chemical, zoobenthic, attached algal and phytoplanktonic standards, the South Basin of Lake Winnipeg was considered mesotrophic (47). Blooms of the blue-green algae, *Microcystis flos-aqua* and *Microcystis aeruginosa* have been observed (47). More recently, shifts in the algal species composition and late summer blooms of blue-green algae have been recognized (49). These blue-green algal blooms, reduce the aesthetic quality of the Lake Winnipeg beaches.

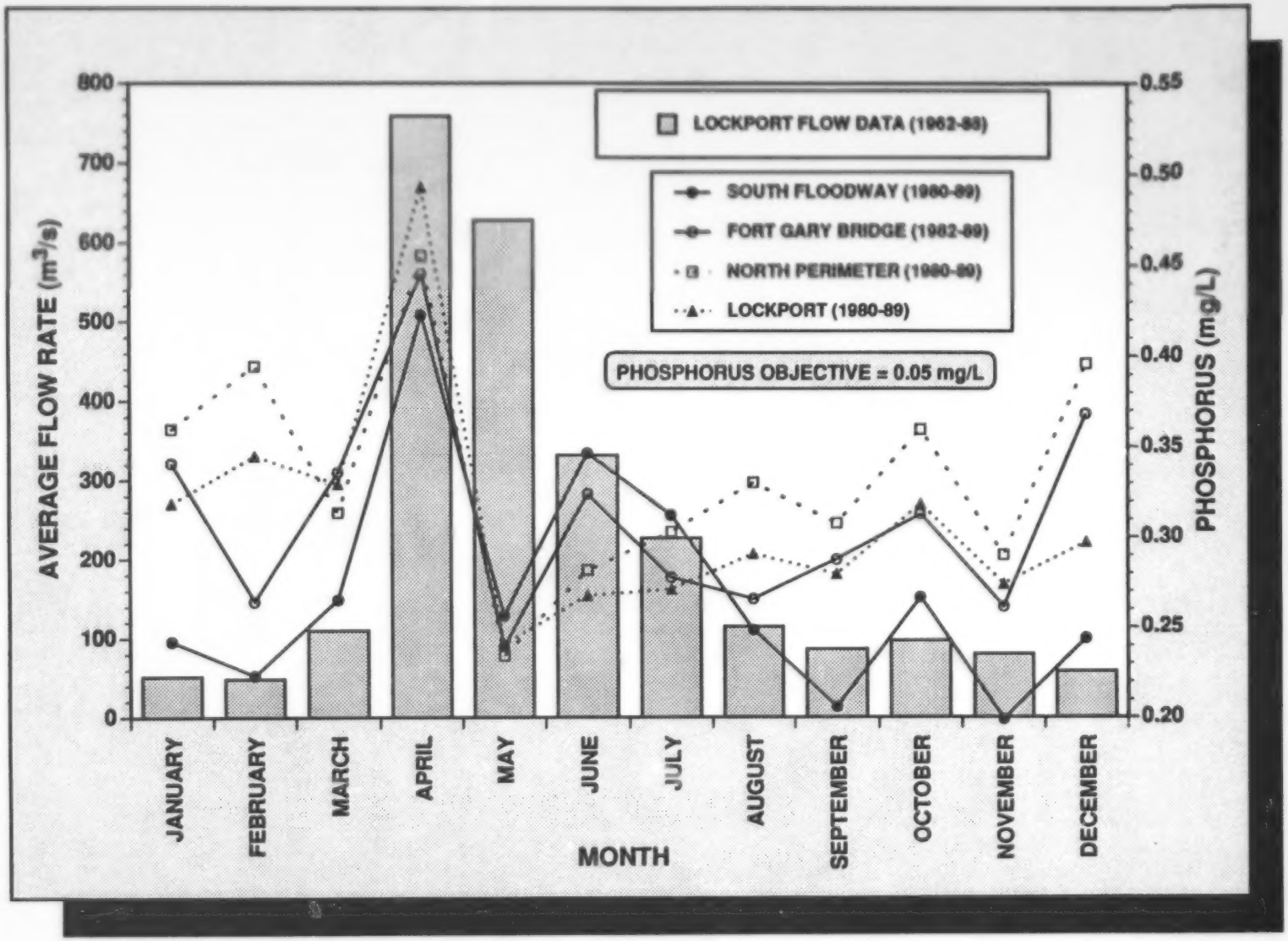


FIGURE 15: Monthly average phosphorus concentrations for sampling locations on the Red River.

The Red and Assiniboine river water quality data indicate that phosphorus is unlikely to be the factor limiting algal growth. Under turbid conditions (i.e high flow periods), light is expected to be limiting growth. However, when turbidity levels drop during periods of lower flow, nitrogen may become the limiting variable. Under conditions of high phosphorus and low dissolved nitrogen, nitrogen-fixing undesirable blue-green algae may proliferate in the rivers or in Lake Winnipeg's South Basin.

6.1.4 INORGANICS AND METALS

6.1.4.1. INORGANICS:

DISSOLVED OXYGEN:

Reduction in the level of available oxygen has a marked effect on many physiological, biochemical and behavioral processes in fish. Low oxygen levels have been shown to influence growth rate, food conversion efficiency, and feeding in some species (50).

For the protection of cool water aquatic life and water, Manitoba has adopted an objective of 47% saturation of oxygen. Figures A82 to A93 present the percent saturation data for the Red and Assiniboine sampling stations. Tables A51 to A60 summarize the data in terms of average monthly and yearly concentrations at sites along the Red and Assiniboine rivers. These results show that oxygen concentrations are rarely below the 47% objective.

Trend analysis indicates that there are no sites which demonstrate a significant decreasing trend, however four of the 12 sites show a significant increasing trend in dissolved oxygen concentration (Table A60). Oxygen levels at Lockport are generally higher than those recorded at the North Perimeter sampling station. In addition, oxygen levels at Selkirk are significantly higher than those recorded at Headingley or the South Floodway site (Table A60). This is largely a result of the Red River being oxygenated as the water passes over the Lockport Dam.

Low percent saturation values generally occur in the winter months, partially as a result of the dependence of the percent saturation on the ambient temperature. Consequently, the oxygen data are also presented as a concentration (Figures A94 to A105).

The EPA has published minimum dissolved oxygen criteria for non-salmonid waters (13):

NON-SALMONID WATERS:

a. Early Life Stages.	
No production impairment	6.5
Slight production impairment	5.5
Moderate production impairment	5.0
Severe production impairment	4.5
Acute mortality limit	4.0
b. Other Life Stages.	
No production impairment	6.0
Slight production impairment	5.0
Moderate production impairment	4.0
Severe production impairment	3.5
Acute mortality limit	3.0

It is therefore recommended that levels of DO should remain above 5 mg/L during the winter months. Levels below 5 mg/L are only occasionally encountered both within and upstream of the City of Winnipeg (Figures A94 to A105).

pH:

The pH of water approximates the activity of free hydrogen ions, and is defined as the negative logarithm of the hydrogen ion concentration. Biological processes, turbulence and aeration influence the pH by varying the concentration of dissolved carbon dioxide. The pH usually increases during photosynthesis and

decreases during respiration processes. The speciation of metals and nutrients, as well as the toxicity of many pollutants are also influenced by the pH (29).

Manitoba Surface Water Quality Objectives for maximum and minimum pH levels have been established for aquatic life and wildlife, primary recreation and agricultural uses (3).

The pH data for all 12 sites on the Red and Assiniboine are illustrated in Figures A106 to A117. The objectives developed for irrigation include greenhouse irrigation (where irrigation is the only source of water), field crop irrigation (where irrigation water is used to supplement natural precipitation), and water used for livestock watering. The objective range for greenhouse irrigation is 6.0 to 8.5 pH units. This objective is exceeded at an average frequency of 2% to 19%, although mean exceedences within summer months range from 0% to 32% (Tables A61, A62, A63, A65, A67 A69, A71, A73, and A75). Exceedences generally decrease downstream of the headwater sites.

Field crop irrigation objectives are set at a pH range of 5 to 9. Exceedence of this range has not been detected at any site during irrigation months. Similarly, exceedences of the livestock watering pH objective (pH 5.5 to 9) has not been detected in the Red or Assiniboine rivers.

The Manitoba Surface Water Quality Objectives range of pH for primary recreational waters is 6.5 to 8.5. This range was established since both alkaline and acidic waters may cause eye irritation. Exceedence of this range occurs at a frequency of 0 % to 24% during the summer months. (Tables A64, A66, A68, A70, A72 and A74). Exceedence frequency generally decreases downstream from the headwater sampling stations.

Exceedence of the 6.5 to 9.0 pH range for cool water aquatic life and wildlife is very rarely exceeded (<1%), and poses no serious environmental concern to the aquatic life. However, an increase in pH, is accompanied by an increase in the the concentration of un-ionized ammonia. Among 11 of the 12 sampling locations that demonstrated an increasing trend in pH, six of these were significant (Table A76). If this trend continues, the exceedence rate of un-ionized ammonia objective may also increase. The Headingley sampling station showed a statistically higher pH compared to the Selkirk station. The two headwater sites were not significantly different nor were the Floodway and Selkirk stations statistically different (Table A76).

INORGANIC CARBON:

Inorganic carbon within aquatic systems is primarily comprised of bicarbonate, carbonate and carbonic acid. The hardness of water is influenced by the quantity of inorganic carbon it contains.

Inorganic carbon levels have been monitored at three sampling stations (Figures A118 to A120). Paired t-test results indicate that the Headingley sampling station has significantly higher inorganic carbon levels than that found in the Red River at the South Floodway or Selkirk station, although the mean difference is less than 5 mg/L (Table A77). The Headingley and Selkirk stations demonstrate significant decreasing trends in the inorganic carbon content of the water, whereas the South Floodway site shows no significant trend (Table A77).

ALKALINITY and HARDNESS:

Total alkalinity is the sum of all components in the water that act to buffer the water against changes in pH. Alkalinity is primarily imparted by the

bicarbonate, carbonate and hydroxide constituents of water.

Alkalinity and hardness data have been monitored at three of the 12 sampling locations (Figures A121 to A123).

Alkalinity values within the Red and Assiniboine Rivers generally range between 100 mg/L to 400 mg/L. The Headingley sampling station is significantly higher in alkalinity as compared to that observed in Selkirk (Table A78). There are no significant differences in alkalinity concentrations between the Headingley and the South Floodway, or the South Floodway and Selkirk stations. Although trend analysis indicates no significant trends in total alkalinity, increasing and decreasing trends for carbonate alkalinity and bicarbonate alkalinity are present (Tables A79 and A80).

Water hardness is a measure of the cations dissolved in water. Magnesium and calcium are considered to be the primary contributors to hardness in water, and hence are used to calculate total hardness. The Headingley station water samples have significantly higher hardness levels compared to the South Floodway and Selkirk stations (Table A81), although the trend analysis indicates a significant decrease at the Headingley station (Table A81).

CALCIUM, MAGNESIUM and POTASSIUM:

The levels of magnesium, calcium and potassium monitored at three sampling stations (Figures A124 to A126), fall within the range reported for other Canadian surface waters (29).

The principal sources of magnesium in surface water are ferromagnesium minerals in igneous rocks and magnesium carbonates in sedimentary rock, with antropogenic contributions generally being low. The surface water at Headingley has significantly higher levels of magnesium compared to the two Red River sampling locations (Table A82), although no significant increasing or decreasing trends can be observed at any of the three sites (Table A82).

Calcium levels at these locations are for the most part, higher than the magnesium levels. Being one of the most abundant cations in surface waters, calcium enters surface water through the weathering of rocks and from the soil, through seepage and runoff. As observed with magnesium levels, calcium concentrations are significantly higher at Headingley than they are at the South Floodway or Selkirk stations (Table A83), with no significant increasing or decreasing trends being apparent (Table A83).

Potassium salts are widely used in agricultural fertilizers and in industry. Consequently, potassium may enter surface waters through natural weathering processes, through industrial effluent discharge or from the leaching of potasssium-bearing soils. Potassium is an essential plant and animal element which is readily accumulated. Levels of potassium do not vary significantly between the Headingley, South Floodway and Selkirk stations (Table A84). Both the Headingley and Selkirk stations indicate a significant decreasing potassium concentration, unlike that observed for calcium and magnesium at these same stations (Table A84).

SULPHATES:

Sulphates can enter surface waters through the leaching of sedimentary rock, or anthropogenically through industrial discharges. Sulphur dioxide released to the atmosphere, can enter surface water through either dry or wet deposition. The Manitoba Surface Water Quality Objectives have set levels of 250 mg/L of

sulphate for the protection of greenhouse and field crop irrigation uses, 600 mg/L for livestock watering, and 500 mg/L for domestic consumption purposes.

Sulphate levels recorded at all three sites are within the recommended objectives (Figures A127 to A129). Sulphate levels are significantly higher at the Headingley station than recorded at the Selkirk or South Floodway station (Table A85), however the data suggest there is a significant decreasing trend at the Headingley site (Table A85). Sulphate levels are significantly higher at Selkirk than those recorded upstream at the South Floodway site, although the mean difference is only 11 mg/L (Table A85). Neither the South Floodway nor the Selkirk site demonstrate any significant increasing or decreasing trend.

MANGANESE:

Although manganese is an essential plant element it can become toxic to plants at high concentrations. Manitoba Surface Water Quality Objectives have been established for manganese levels in water used for irrigation purposes and for domestic consumption (3)

At the Headingley site, greenhouse irrigation and field crop irrigation objectives are exceeded at a frequency of 20% (Figure A130). At the South Floodway site, exceedence of the greenhouse and field crop irrigation objectives have occurred at a frequency of 24% (Figure 131). The Selkirk sampling site has a 8% exceedence of the greenhouse field crop irrigation objective (Figure 132).

An objective of 0.05 mg/L of manganese has been set for domestic consumption. This objective is exceeded 92% of the time at the Selkirk sampling station, however Selkirk's water treatment process should remove between 90% to 100% of the manganese (51).

There are no significant increasing or decreasing trends in manganese concentrations upstream or downstream of Winnipeg. Manganese levels are significantly higher in the Assiniboine than they are at either of the two sites on the Red River (Table A86). The South Floodway and the Selkirk sites are not significantly different (Table A86).

CHLORIDE:

Manitoba Surface Water Quality Objectives for chloride have been established to protect irrigation and domestic consumption uses (3). Chloride is an essential plant element, however damage can occur if excess chloride is transported to the leaves through root absorption or by direct foliar absorption. Some of the pathways by which chloride enters surface waters include the weathering and leaching of sedimentary rocks and soil; the dissolution of salt deposits, municipal and industrial effluent discharge; salting of highways; and from irrigation drainage.

At the Headingley sampling station, there have been no exceedences of the irrigation objectives (Figure A133). On the Red River at the South Floodway site (Figure A134), the greenhouse irrigation objective of 68 mg/L has been exceeded at a rate of 26%, and the field crop irrigation objective of 150 mg/L was exceeded on one occasion (*i.e.* frequency = 5%). Downstream at the Selkirk site, the greenhouse irrigation objective has been exceeded 26% of the time and the field crop irrigation objective has been exceeded at a frequency of 7% (Figure A135). These exceedences are generally in winter months and may be a result of periodic winter melt-water carrying salt from city streets into the storm sewers. Since flow rates are low during the winter months, this chloride input is detected more

readily than it is in the spring when river flow rates are high.

The Selkirk and South Floodway sites are significantly higher in chloride concentrations, when compared to those observed at Headingley (Table A87). However, the Selkirk site is not significantly different than the South Floodway site. Trend analysis indicates that there is a significant increasing trend in chloride concentrations at both sites on the Red River, however a significant decreasing trend occurs at the Headingley site on the Assiniboine River (Table A87).

The domestic consumption objective of 250 mg/L has not been exceeded at Selkirk during any of the sampling periods (Figure A135).

SODIUM:

Sodium, an essential element required by both plants and animals, bioaccumulates readily. Excess sodium can impair plants through toxicity from direct root uptake or foliage uptake; nutritional imbalance, impairment of physical soil conditions; or through osmotic stress.

Manitoba Surface Water Quality Objectives have been established for both domestic consumption and greenhouse irrigation use. Figures A136 to A138 illustrate sodium levels at three sampling stations. Concentrations over the 400 mg/L domestic consumption objective have not been encountered (Figure A138). The 20 mg/L irrigation objective is exceeded frequently at all sites (Figures A136 to A138), and there is no significant difference in concentration between these stations (Table A88). Trend analysis indicates a significant decreasing trend in sodium concentrations at Headingley and no significant trend at the South Floodway or Selkirk sites (Table A88).

SODIUM ADSORPTION RATIO:

The suitability of water for irrigation purposes can be evaluated through the calculation of the sodium adsorption ratio (SAR). This ratio is based on the concentration of sodium, calcium and magnesium. The ratio is an estimate of the degree to which sodium will be adsorbed from the water by the soil. Excess sodium in irrigation water relative to calcium and magnesium can adversely affect soil structure and the rate at which water moves into and through soil (29). The following table categorizes the effects of sodium on plants:

Table 25: Sodium adsorption ratio as it relates to the suitability of water for irrigation use (29).

SAR (Irrigation Water)	Restriction on Use
<3	none
3-9	slight to moderate
>9	severe

The SAR data for sites on the Red and Assiniboine Rivers generally fall within the range of 0.2 to 4.2, indicating good suitability for irrigation purposes (Figures A139 to A141). The ratios are not significantly different between sites on the Red and Assiniboine, however the trends do differ (Table A89). Though there is a significant increasing trend at the South Floodway site, the Headingley station suggests a significant decreasing trend. (Table A89). At Selkirk, where there is a much longer period of record, there has been no significant change.

ARSENIC:

The arsenic content in fresh waters is dependent on the geochemistry of the region and the proximity to

industrial activity and other human activities (29). Arsenic bioaccumulation has been observed in numerous aquatic organisms (29). Due to the toxicity of arsenic to flora and fauna, Manitoba Surface Water Quality Objectives have been developed for domestic consumption, aquatic life and wildlife, and for agricultural uses.

Prior to 1985, arsenic levels were measured as "extractable arsenic", whereas after 1985, "total arsenic" levels were monitored. There has been no exceedence of the Manitoba Surface Water Quality Objectives established for arsenic, at any of the three sampling stations (Figures A142 to A144). There is also no significant difference in arsenic concentrations between any of these stations (Table A90).

BORON:

Boron can enter surface waters through the weathering of sedimentary and igneous rocks, or through soil leaching processes (29). Boron can also be found in domestic sewage as it is widely used for both industrial and household purposes. Boron is used in agriculture as both a plant nutrient and as a component in pesticides. Although boron is an essential plant nutrient, it can also be toxic at high concentrations.

Objectives for boron in domestic water supplies have been developed since consumption of large amounts of boron can affect the central nervous system (52). Objectives have also been established for greenhouse irrigation, field crop irrigation and livestock watering (3). The surface water at the Headingley, South Floodway and Selkirk stations all contain acceptable levels of boron (Figure A145 to A147). There is no significant difference in the concentration of boron at these locations, although both sites on the Red River indicate significant increasing trends (Table A91).

6.1.4.2. METALS:

The bioavailability and speciation of metals are influenced by factors such as temperature, hardness, pH, redox potential, carbon dioxide and the presence of chelating compounds (29). Metals do not degrade, but are transferred and stored within an aquatic system. Metals may exist in the soluble form as simple or complex free metal ions, ion pairs, coordination compounds or un-ionized organometallic chelates or complexes (29). Complexes may be formed with particulate material including clay and organic matter.

The effects of metal exposure on physiological processes is both variable and complex. Since toxicity of metals varies with the speciation of the metal, separate objectives for each form of metal are needed. The difficulty in measuring these different forms, and determining the relative toxicity of each, has lead to the development of objectives based on the total concentration as a protective measure (29).

IRON:

Iron is released into surface water through both weathering and leaching activities. Anthropogenic sources originate from a number of industrial processes. Sewage can also be a source of iron loading to surface waters (29).

Manitoba Surface Water Quality Objectives for iron have been developed for domestic consumption, aquatic life and wildlife, and for irrigation purposes. The toxicity of iron is variable amongst invertebrates and fish. Excess iron in the soil can interfere with plant growth, as precipitated iron can bind with phosphorus and molybdenum, making them unavailable for use. Precipitated iron can also cause damage to plants by coating the leaves (29). A maximum

level of iron in drinking water has been established on the basis of aesthetic considerations.

Iron concentrations have been monitored at the Headingley, South Floodway and Selkirk sampling stations (Figures A148 to A150). The 1.0 mg/L aquatic life and wildlife objective was exceeded at a rate of 20% at Headingley and Selkirk, and by 40% at the South Floodway site. The objectives set for irrigation purposes were exceeded only once at these stations. The objective of 0.20 mg/L iron for domestic water, was exceeded 60% of the time at Selkirk, however the water treatment process should remove 90% to 100% of the iron (51).

There is no significant difference in iron concentrations among the three locations (Table A92). However at Selkirk, where there is a much longer period of record, there has been a significant increasing trend in concentration (Table A92). The highest average iron concentration is found at Headingley, followed by the South Floodway and the Selkirk station. These data suggest there is little additional input of iron to the rivers as they flow through Winnipeg.

COPPER:

Guidelines for copper concentrations in surface water used for agriculture, domestic consumption and by aquatic life and wildlife have been developed. The toxicity of copper to aquatic life is related to the water hardness, therefore the Manitoba Objectives for aquatic life and wildlife is a calculated value based on this variable.

Exceedence of the aquatic life and wildlife objective was recorded on one occasion at the Selkirk station, and no exceedences have been detected for the agricultural objective at any of the three locations (Figures A151 to A153). Concentrations of copper at the Headingley, South Floodway and Selkirk stations were regularly not detected, therefore t-tests and trend analysis were not performed.

LEAD:

Anthropogenic input of lead into the environment exceeds all natural sources. Lead reaches the aquatic environment through municipal and industrial wastewater discharge, as well as by precipitation, fallout of lead dust and leaded gasoline runoff from streets (29). Lead will bioaccumulate in bacteria, invertebrates, fish and plants.

Manitoba Surface Water Quality Objectives have been developed for levels of lead in surface waters used by aquatic life and wildlife and for surface waters used for domestic consumption, livestock watering and irrigation purposes. Lead concentrations at the Headingley, South Floodway and Selkirk stations were generally not detected and recorded at the detection limit of 0.005 mg/L (Figures A154 to A156). Manitoba objectives set for lead levels in water used for domestic consumption, livestock watering and irrigation purposes, were not exceeded at these three locations.

The objective set for aquatic life and wildlife is a calculated value based on the water hardness. Acute toxicity of lead is greater in soft water than in hard water. Exceedence of this objective has occurred once at the South Floodway, and twice at Selkirk, with no exceedences recorded at the Headingley station.

Concentrations of lead at the Headingley, South Floodway and Selkirk stations were regularly not detected, therefore paired t-tests and trend analysis were not performed.

NICKEL:

Nickel toxicity to aquatic life is variable and is dependent on the water hardness. Objectives for nickel concentrations in irrigation water have been developed since decreased yields may occur with high levels of nickel in the soil (29).

Nickel concentrations in water samples collected at Headingley, the South Floodway and at Selkirk are mostly at or near the detection limit of 0.005 mg/L (Figures A157 to A159). There has been no exceedence of the objectives at these three sampling locations.

Concentrations of nickel at the Headingley, South Floodway and Selkirk stations were regularly not detected, therefore paired t-tests and trend analysis were not performed.

ZINC:

Zinc can enter surface water via natural or anthropogenic sources. Iron and steel production, waste incineration, wood combustion and municipal wastewater are some of the anthropogenic sources (29). Chronic and acute toxicity of zinc is highly variable in invertebrates and fish.

Manitoba objectives have been established for the concentration of zinc in surface water used for domestic consumption, agriculture and aquatic life. Figures A160 to A162 illustrate levels of zinc at the Headingley, South Floodway and Selkirk sampling stations. Many of the samples had zinc levels which were at or below the 0.01 mg/L analytical detection limit.

The objectives set for agricultural use and domestic consumption have not been exceeded, however exceedences of the aquatic life and wildlife objective of 0.047 mg/L have been observed at all three locations. At Headingley, one of the 25 samples exceeded the objective. On the Red River, exceedences were somewhat more frequent. Both the Selkirk and South Floodway stations exceeded the 0.047 mg/L objective at a rate of 11%. This suggests that there is probably not a significant loading of zinc to the Red River as it flows through Winnipeg.

Concentrations of zinc at the Headingley, South Floodway and Selkirk stations were regularly at or below the detection limit, therefore t-tests and trend analysis were not performed.

CHROMIUM:

Chromium is bioaccumulated by aquatic organisms (29). Hexavalent chromium is monitored at the Headingley, South Floodway and Selkirk stations. Due to the toxicity of this form of chromium to aquatic life, Manitoba has adopted an objective of 0.011 mg/L. None of the hexavalent chromium concentrations have been above the analytical detection limit of 0.02 mg/L.

6.1.5. PESTICIDES AND OTHER ORGANICS:

6.1.5.1 ORGANICS:

TOTAL ORGANIC CARBON:

Organic carbon sources within aquatic systems may originate from plant and animal material, from agricultural runoff, and from municipal or industrial discharges. Organic carbon is composed of both dissolved and particulate forms. Total organic carbon is often calculated as the difference between total carbon and total inorganic carbon. Lakes and rivers generally have about 10 times more dissolved inorganic matter as organic matter (29). Excessive quantities of organic

carbon are undesirable since these can lead to an increase in the biological oxygen demand (BOD).

Levels of carbon at sampling sites along the Red and Assiniboine rivers are illustrated in Figures A163 to A174. The concentration of organic carbon at these locations varies from 1 to 68 mg/L. Table 26 summarizes the data for sites along the Red and Assiniboine Rivers.

The paired t-tests indicate that there is no significant difference in the average concentration of organic carbon upstream versus downstream of the sewage effluent discharge sites (Table A93). Trend analysis demonstrated that nine of 12 sampling stations on the Red and Assiniboine Rivers have significant decreasing trends in organic carbon concentrations (Table A93). The dissolved oxygen data (Figures A82 to A93) also indicate that there are not large biological oxygen demands resulting from municipal wastewater discharge. These improved conditions are at least partly a result of improvements in the sewage treatment process in Winnipeg.

TABLE 26: Summary statistics for total organic carbon concentrations in the Red and Assiniboine rivers (1980-1989).

SAMPLING LOCATION	MEAN	STANDARD DEVIATION	N	STANDARD ERROR	MINIMUM	MAXIMUM
RED RIVER SITES:						
WQ445 FLOODWAY CONTROL	17.6	6.1	242	0.39	1.0	46.0
WQ576 FORT GARY BRIDGE*	16.0	5.3	147	0.43	6.0	34.0
WQ447 NORWOOD BRIDGE	17.1	6.6	229	0.44	4.0	41.0
WQ448 REDWOOD BRIDGE	16.6	6.2	234	0.40	2.0	44.0
WQ449 NORTH PERIMETER	16.7	6.2	237	0.40	2.0	43.0
WQ450 LOCKPORT BRIDGE	16.4	5.8	241	0.37	2.0	39.0
ASSINIBOINE RIVER SITES:						
WQ451 HEADINGLEY	15.2	8.0	235	0.52	1.0	68.0
WQ452 WEST PERIMETER	15.4	6.9	237	0.44	2.0	46.0
WQ453 MAIN STREET BRIDGE	15.2	7.5	227	0.50	1.0	64.0

* Data collected from 1982-89.

6.1.5.2. PESTICIDES

Many commercial and domestic gardening and horticulture operations are located adjacent to rivers and streams to gain access to an inexpensive water supply source. This form of agriculture often involves the use of pesticides which have the potential to enter adjacent water bodies through surface runoff. Other input sources include accidental or intentional application to surface waters, areal drift during spraying and sediment deposition during soil erosion. Pesticide inputs to the rivers within Winnipeg are also

possible from non-adjacent riverbank domestic and commercial operations through storm sewer drainage.

An investigation of pesticide contamination of the La Salle and Assiniboine rivers in Manitoba found that the concentrations in these rivers did not pose a significant threat to humans (20). The levels were below those recommended by Health and Welfare Canada in drinking water. In this study, two of the herbicides, trifluralin and triallate, were not detected in the water but were quantified in fish and bottom sediments. These results suggest that bioaccumulation of these two herbicides can occur even at low exposure levels.

PCB and pesticide residues in fish from the Red River were evaluated between 1978-1983 (53). Fish collected from Emerson, St. Norbert and Selkirk showed statistically significant negative trends which indicated an exponential rate of decline in total PCB residues between 1978-1983. Residues of total DDT were representative of long-term background levels. For the few organochlorine insecticides that were detected in the fish tissue, none exceeded the existing Canadian guidelines (53).

Tables A94 to A96 illustrate pesticide concentrations in surface water collected from three sampling locations.

Lindane is an insecticide used domestically and commercially to control biting insects. The remaining pesticides listed in these tables are herbicides registered for use in Canada. Many of these herbicides are used to control broadleaf weeds (54).

Pesticide concentrations in surface water sampled from the Red and Assiniboine rivers, rarely above the analytical detection limits. At Headingley, trifluralin, lindane and picloram were above detection limits only once, with the remaining pesticides never above the detection limit (Table A94).

Upstream of Winnipeg on the Red River, triallate, propanil, simazine and atrazine were not recorded above detection limits, with the remaining pesticides being detected either one or two times from 1985 to 1989 (Table A95).

Downstream of Winnipeg, at Selkirk, dicamba, bromoxynil and 2,4-D were frequently recorded above their detection limits (Table A96). Trifluralin, lindane and picloram were occasionally detected, and MCPA was found above detection limits on one occasion. The concentrations of the remaining five pesticides, were not found above detection limits between 1985-1989. Pesticide concentrations at the Headingley, South Floodway and Selkirk stations were frequently at the detection limit, therefore paired t-tests and trend analysis were not performed.

These results suggest that within or downstream of the City of Winnipeg, there is some additional input of pesticides into the Red River. Trifluralin concentrations are generally higher during the spring, suggesting that spring melt (February to April) is facilitating the movement of this herbicide into the Red River. Higher levels of 2,4-D appear to occur most frequently in the spring and fall, although levels above detection limits also occur at other times of the year. Heavy rains and spring melt are likely carrying substantial quantities of 2,4-D, which have been applied to both domestic and commercial lawns for the control of broadleaf weeds. The levels of 2,4-D found in water samples collected from Selkirk, are all well below the 100 µg/L Manitoba Surface Water Quality Objective established for domestic consumption.

Considering those pesticides for which Manitoba Surface Water Quality Objectives have been defined (3),

the levels of pesticides at all three sites are within the objectives established for the protection of the existing water uses.

6.2 TRIBUTARY WATER QUALITY

The water quality data base for the tributaries is not as comprehensive as exists for the Red and Assiniboine rivers. There is no current water quality data available for Baldry Creek, Grassmere Creek, Bottomly Creek, Parks Creek, Gunn's Creek, Mirey Creek, Cook's Creek, Netley Creek or Devils Creek.

Prior to 1988, Manitoba Environment sampled the Seine and La Salle rivers at various locations on a intermittent basis. In July of 1988 Manitoba Environment established permanent monitoring stations on the Seine River (at the perimeter highway) and La Salle River (at Highway #75). At these sites, 57 variables are monitored quarterly. This data is not presented in this report due to the limited nature of the data base. A copy of this data can be obtained by contacting the Water Quality Management Section of Manitoba Environment.

The City of Winnipeg data were utilized for the following water quality assessment. The City of Winnipeg collects data from seven stations in five of the tributaries (Table 23). The 1980 to 1989 data has been collected on a monthly interval during the open water season.

The water quality within the tributaries is influenced by both point and non-point discharge. Point source discharge is attributed to storm water sewers and combined sanitary and storm sewers. In addition some of the tributaries receive wastewater discharge from treatment plants in municipalities surrounding the City of Winnipeg. Non-point pollution, such as nutrients and pesticides, occur as a result of direct runoff into the tributaries.

6.2.1 BACTERIOLOGICAL PARAMETERS:

Fecal coliform data collected from the tributaries are illustrated in Figures A175 to A181. Due to the existing and potential secondary recreation and irrigation uses on the tributaries, a fecal coliform density of 1000/100 mL is proposed for all the tributaries within the classification area. For all sampled tributaries, the exceedence frequency of this objective has been calculated (Table A97).

These results illustrate that Bunn's Creek and the Sturgeon Creek site at Portage Avenue, have the highest incidence of fecal coliform exceedences at 35% and 29% respectively. Since fecal coliform exceedences are rare at the Sturgeon Creek site at the perimeter highway, point source discharges from within the City of Winnipeg are expected to be primarily responsible for these elevated fecal coliform densities.

Between the Seine River site upstream of the City at Highway #59 and the site at the Provencher Bridge, the rate of exceedence increases from 2% to 8% (Table A97). The maximum fecal coliform density recorded in the Seine River (1,500/100 mL) is considerably lower than the maximum values recorded in Sturgeon Creek (24,000/100 mL) and Bunn's Creek (150,000/100 mL).

There are no significant increasing or decreasing trends in fecal coliform densities at any of the seven stations (Table A98).

6.2.2. PHYSICAL PARAMETERS:

TURBIDITY:

There are no Manitoba Surface Water Quality Objectives proposed for turbidity levels in the tributaries due to the unsuitability of these waters for swimming. The historic data for turbidity levels in the tributaries are presented in figures A182 to A188.

Average turbidity values range from 12 to 33 NTU, although minimum and maximum values range from 1.5 to 400 NTU (Table A99). There are no significant increasing or decreasing turbidity trends, in any of the tributaries (Table A100).

CONDUCTIVITY:

Water having high conductivity is undesirable for irrigation use as it will reduce the availability of water for plant growth. A conductivity objective of 1500 µS/cm is proposed for the tributaries to protect irrigation use. For those tributaries which have existing and future use for livestock watering, an objective of 4300 µS/cm is proposed. The conductivity data is presented in figures A189 to A195.

Table A101 illustrates the degree of compliance with the irrigation objective. Both sites at Sturgeon Creek and the Omand's Creek site show high rates of exceedence. The average conductivity levels in these two creeks are two to three times higher than those recorded in the other three tributaries. There have been two exceedences of the livestock watering objective on Sturgeon Creek (Table A102).

The history of high conductivity levels in Sturgeon Creek are likely in part attributable to the Manitoba Hyrdo Dorsey Converter Station which previously discharged brine water into Sturgeon Creek. Manitoba Hydro is now disposing of their waste brine water by deep well injection. Currently, the only industrial water discharged to Sturgeon Creek is cooling water. The significant decreasing trend in conductivity at the perimeter sampling station in Sturgeon Creek, reflects this change in waste disposal (Table A103).

Previous practice of snow dumping in the tributaries may also have been a contributing factor to high conductivity. Bunn's Creek data indicate a significant decreasing trend in conductivity (Table A103). This may be partially attributable to bank stabilization resulting from the development of Bunn's Creek Linear Park.

The data collected from the Seine River at Highway #59 illustrates the lowest average conductivity level for all of the tributaries (Table A101), however there is a significant increasing trend at this site (Table A103).

6.2.3. NUTRIENTS:

NITRATE/NITRITE:

Nitrate inputs to the tributaries are likely a result of soil leaching. Elevated nitrate levels can follow rainfall events, as inorganic nitrate fertilizers are carried into the creeks with storm water. As observed in the Red and Assiniboine, early melt water can contain high levels of nitrate/nitrite, relative to phosphorus concentrations.

Municipal wastewater flows contribute to the nitrogen loading, primarily as ammonia, although ammonia is oxidized to nitrate and nitrite once in the receiving stream. Excessive nitrogen loading in the

form of nitrate and ammonia, can contribute to nuisance aquatic weed and algal growth.

Average nitrate/nitrite concentrations range from a low of 0.11 mg/L in the Seine River at Highway #59 to a high of 0.28 mg/L in Sturgeon Creek at Portage Avenue (Figures A196 to A202, Table 104). The livestock water objective for nitrate/nitrite has not been exceeded (Table A104). Trend analysis suggests that there are no significant increasing or decreasing trends at any of the sampling stations (Table A105)

PHOSPHORUS:

Phosphorus concentrations in the tributaries are influenced by both point and non-point loading sources. Sewer outfalls and direct runoff have the potential to contribute significantly to the phosphorus content of the surface waters. Manitoba has adopted an objective for total phosphorus concentrations to limit the extent of extensive algal blooms and aquatic weed growth which may render the water unsuitable for other beneficial uses (3). The objective is set for general guidance, and may not be applicable in surface waters where nuisance growth is limited by other factors. Factors limiting plant growth in the tributaries have not been thoroughly investigated to date.

Phosphorus concentrations vary substantially between tributaries (Figures A203 to A209). The La Salle River and Bunn's Creek have the highest mean phosphorus concentrations at 0.32 mg/L and 0.35 mg/L respectively (Table A106). Omand's and Sturgeon Creeks maintain the lowest phosphorus concentrations at 0.14 mg/L and 0.15 mg/L respectively. However, all tributaries have a high rate of exceedence of the 0.05 mg/L objective (Table A106).

Increasing trends in phosphorus concentrations were identified at four of the seven sites (Table A107).

6.2.4. INORGANICS:

pH:

pH objectives relating to irrigation water, livestock watering and aquatic life and wildlife apply to the tributaries.

Figures A210 to A216 illustrate the range of pH data for the five sampled tributaries. Average pH conditions are highest in the La Salle River and lowest in Sturgeon Creek (Table A108).

Exceedence of the pH objectives are rare. For irrigation use, only one exceedence has been recorded in each of Omand's Creek and the La Salle River (Table A108). These same two tributaries have exceeded the cool water aquatic life and wildlife objective, again on one occasion (Table A109). The livestock watering objective has been exceeded on one occasion in the La Salle River (Table A110).

Although the trend in most tributaries is towards an increasing pH, there was no statistically significant trends in this water quality variable (Table A111).

DISSOLVED OXYGEN:

To support the aquatic life within the tributaries, a minimum dissolved oxygen should be maintained. By ensuring protection of the aquatic communities, protection is indirectly afforded to wildlife that rely upon the surface water for food or habitat. A minimum 47% saturation is recommended to support the aquatic life in the tributaries within the classification area.

The range of dissolved oxygen conditions in the five tributaries is illustrated in Figures A217 to A233. In Omand's Creek and the La Salle River, there were no

samples collected that had less than a 47% saturation level (Table A112), and there was no trend towards decreasing oxygen levels (Table A113). Sturgeon Creek has maintained a good oxygen level (Table A112), however there is indication of a significant decreasing trend at both sampling sites in the creek (Table A113). The Seine River site at Highway #59 has a somewhat higher oxygen level than the downstream site located at the Provencher Bridge (Table A112). There is a significant decreasing trend observed on the Seine River at the Highway #59 site (Table A113). The Bunn's Creek site has the lowest average oxygen concentration at 64.9%, and the highest rate of exceedence of the 47% objective (Table A112). Approximately 20% of the time, oxygen levels are below the objective, with no significant apparent long-term increasing or decreasing trend (Table A113).

6.2.5. ORGANICS:

TOTAL ORGANIC CARBON:

Organic carbon sources within these tributaries may originate from plant and animal material, agricultural runoff, and municipal discharges. Excessive quantities of organic carbon is undesirable since it can lead to an increase in the biological oxygen demand, and oxygen depletion. There are no Manitoba Surface Water Quality Objectives established for total organic carbon concentrations in surface waters.

Figures A224 to A230 illustrate the range of total organic carbon concentrations in each of the five tributaries. Average total organic carbon concentrations range from a low of 13.1 mg/L in Sturgeon Creek at the perimeter to as high as 21.0 mg/L in the Seine River at Highway #59 (Table A114). Historically, the Seine River, followed by Bunn's Creek and the La Salle River, have the highest concentrations of organic carbon.

Only the two sampling sites in the Seine River indicate a significant increasing trend in organic carbon (Table A115). This significant increase is expected to contribute to the significant decreasing trend in oxygen levels observed at the Provencher Bridge site (Table A113).

6.3 WATER QUALITY SUMMARY

The classification area falls within the most heavily populated area of Manitoba. Consequently the waters within the classification area are some of the most heavily impacted in the province. These surface waters receive limited industrial wastes and significant municipal wastes.

This report has documented the use of the rivers and streams for recreation, irrigation, domestic and industrial consumption. The aquatic life downstream of Winnipeg is both an ecologically and economically significant resource.

The following section summarizes the most significant water quality concerns in the classification area.

6.3.1 MICROBIOLOGICAL QUALITY:

1. The microbiological quality of the Red and Assiniboine Rivers, within and downstream of Winnipeg, is not of sufficient quality to support the existing uses.

2. The microbiological quality in the tributaries indicate that Bunn's Creek and Sturgeon Creek often exceed the secondary recreation and irrigation objective.

3. Achieving improved water quality conditions will not only reduce the risk of water-borne illnesses, but will also ensure that downstream users are not unreasonably impacted as a result of upstream loading.

6.3.2. UN-IONIZED AMMONIA TOXICITY:

1. Acute toxic responses of fish to un-ionized ammonia includes loss of equilibrium; hyperexcitability; increased breathing, cardiac output and oxygen uptake; convulsions, coma and death. Chronic responses include a reduction in hatching success; reduction in growth rate and morphological development; and pathological changes in the tissues of gills, livers and kidneys (41).

2. Effluent discharge from within the City of Winnipeg contributes a significant amount of ammonia to the Red and Assiniboine rivers.

3. Average exceedences range from 7% to 44%, although monthly exceedences range as high as 59%.

4. There is a significant increasing trend in ammonia concentrations in the Red and Assiniboine rivers within and downstream of Winnipeg. There has been no significant trend in the ammonia levels immediately upstream of Winnipeg.

5. The exceedence frequency of the un-ionized ammonia objective suggests that sublethal impacts may be occurring.

6.3.3. NUTRIENT LOADING:

PHOSPHORUS:

1. There is a significant input of phosphorus to the Red and Assiniboine rivers from within the City of Winnipeg. Phosphorus levels downstream of Winnipeg are 30% higher than upstream of the city.

2. Exceedence of the Manitoba Surface Water Quality Objectives occur over 99% of the time upstream, within and downstream of the City of Winnipeg. The tributaries also demonstrate a high rate of exceedence. However, phosphorous may not be the factor limiting plant growth at some times of the year.

3. Trend analysis indicates that phosphorus concentrations are significantly increasing only at the Fort Gary Bridge sampling location. Other locations show no significant increasing or decreasing trend.

4. Phosphorus is unlikely to be the limiting algal growth factor in the rivers under turbid conditions.

NITROGEN:

1. Statistically higher levels of nitrate/nitrite and total Kjeldhal nitrogen are found at the Selkirk site compared to those upstream sites at Headingley and the South Floodway control.

2. There is a significant increasing trend in total Kjeldhal nitrogen and ammonia concentrations within and downstream of Winnipeg.

3. Nitrate/nitrite loading occurs primarily through non-point sources, whereas, ammonia loading occurs primarily from point source loading.

6.3.4. OXYGEN:

1. Oxygen levels in the Red and Assiniboine are sufficient to support a cool water fishery.

2. There is a significant increasing trend in oxygen concentrations at some of these water quality stations.

3. The tributaries generally maintain an oxygen level well over the 47% saturation objective during the summer months, however average exceedences of 11% and 19% have been recorded for the Seine River and Bunn's Creek respectively.

6.3.5 PESTICIDES:

1. Pesticide concentrations in surface water sampled from the Red and Assiniboine rivers, are often not above the analytical detection limits.

2. Within or downstream of the City of Winnipeg, there is some additional input of pesticides into the Red River.

3. Considering those pesticides for which Manitoba Surface Water Quality Objectives have been defined (3) the levels of pesticides in the Red and Assiniboine rivers are within the objectives established for the protection of the existing water uses.

7.0 SUMMARY AND MORE INFORMATION

The upcoming Clean Environment Commission hearings will establish Water Quality Objectives for the rivers and their tributaries within and downstream of Winnipeg.

Manitoba Environment has released its proposal to stimulate discussion and encourage people to become involved in the public hearings. We invite you to review the data, develop your own proposals, and present your views to the Clean Environment Commission.

Current water uses and their impact on water quality, raise several questions which are of concern to the Government of Manitoba and may be of concern to you. For example:

- Should the water quality be improved so the river could safely be used for all recreation?
- Should the rivers and streams which contain high levels of fecal bacteria continue be used as an irrigation source for parks and golf courses?
- Should contaminated river water continue to be used to irrigate fruit and vegetables which may be consumed without adequate washing?
- Should the ammonia level in sewage effluent be decreased to ensure a healthy and viable aquatic life community downstream of Winnipeg?
- Is there enough use of the river to warrant the costs of upgrading the City of Winnipeg's sewage treatment systems?

OPTIONS:

The first step in the process is identifying which water uses should be protected. Since there may be significant costs associated with improving water quality conditions, the relative importance of these water uses must be identified. Some of the options Manitobans face include:

- Accept the current water quality impairments, and discontinue use for some recreation and irrigation activities.
- Accept the current water quality impairments and continue existing uses, introduce alternate programs such as public warnings, and bear the increased risks associated with using degraded water.
- Improve the current water quality over a feasible time frame.

WHAT THE PUBLIC HEARING WILL DO:

Setting water quality objectives for the rivers and tributaries is important for a number of reasons. The following provides examples of the effect these hearings will have:

- Water Quality Objectives will be set to protect identified beneficial water uses in the rivers and tributaries within and downstream of Winnipeg.

- These water quality objectives will be applied to all new environmental licensing of municipal and industrial dischargers. Existing dischargers may be required to develop an implementation strategy to upgrade existing facilities.

- This may mean improvements to the City of Winnipeg and other existing waste water treatment systems. Future upgrading options include the disinfection of sewage effluent, an ammonia removal process, and the separation of sanitary and storm sewers.

- Enhancement plans may be initiated to improve water quality to meet the desired water uses. Examples of such programs may include enhancement of aquatic habitat for fish or other wildlife or the creation of buffer zones to reduce non-point pollution loading.

BECOME INVOLVED:

Encourage your family, friends, neighbors and co-workers to become involved. Discuss your ideas and concerns with others. The decisions made at these hearings will affect both the present and future generations of Manitobans. Be part of that decision-making process.

YOUR OPINIONS COUNT

Provide the Clean Environment Commission with your opinions. Technical documents and other non-technical general information are available to help you prepare. Public submissions and presentations, written or verbal, are encouraged and welcomed. (Note: The Commission prefers written submissions.)

TO LEARN MORE ABOUT THE HEARING PROCESS

Please contact:

CLEAN ENVIRONMENT COMMISSION
Towne Square
P.O. Box 21410
284 Reimer Avenue
Steinbach, Manitoba
R0A 2T3

Call Collect 326-2395
Toll free 1-800-282-8069
Fax 326-2472

TO OBTAIN MORE TECHNICAL, NON-TECHNICAL & OTHER INFORMATION

Please contact:

Sharon Gurney
Water Quality Management Section
Manitoba Department of Environment
Building 2, 139 Tuxedo Avenue
Winnipeg, Manitoba
R3N 0H6

Telephone 945-7114
Fax 945-5229
Toll free 1-800-282-8069 (extension 7114)

Or visit the Public Registries located at:

- The Resource Centre, Manitoba Environment, Building 2, 139 Tuxedo Avenue, Winnipeg.
- Selkirk Community Library, P.O. Box 388, 303 Main Street, Selkirk.
- Legislative Library, 200 Vaughan Street, Winnipeg.
- Centennial Public Library, 251 Donald Street, Winnipeg.

8.0
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Proposed Water Quality Objectives
through Manitoba's Watershed Classification Process:

Red and Assiniboine Rivers and their tributaries within and downstream of the City of Winnipeg

Appendix A: Water Quality Data Summary

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July, 1991

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FIGURE A1: Fecal coliform density in the Assiniboine River at site WQ018 at Headingley.

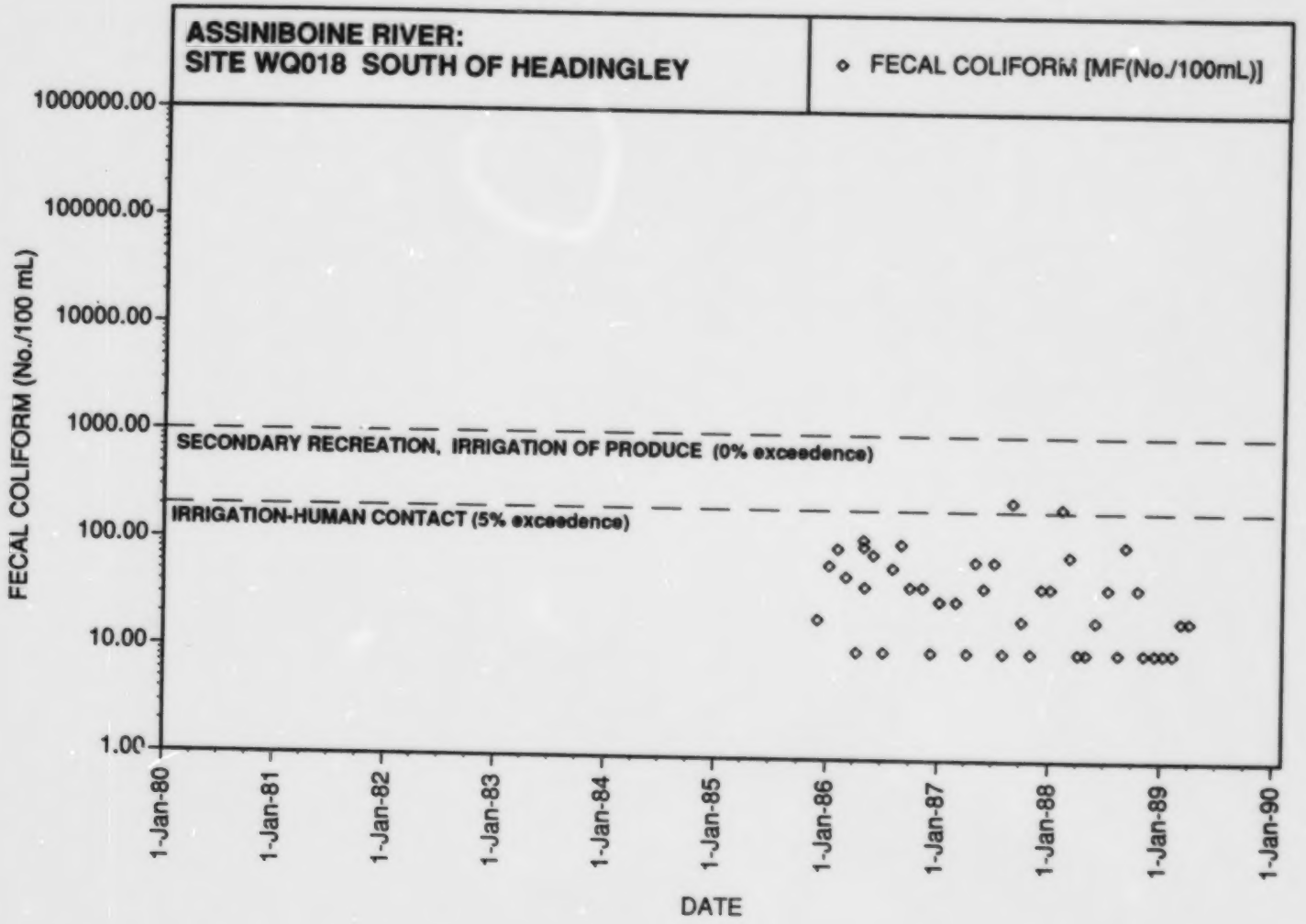


FIGURE A2: Fecal coliform density in the Assiniboine River at site WQ451 at Headingley.

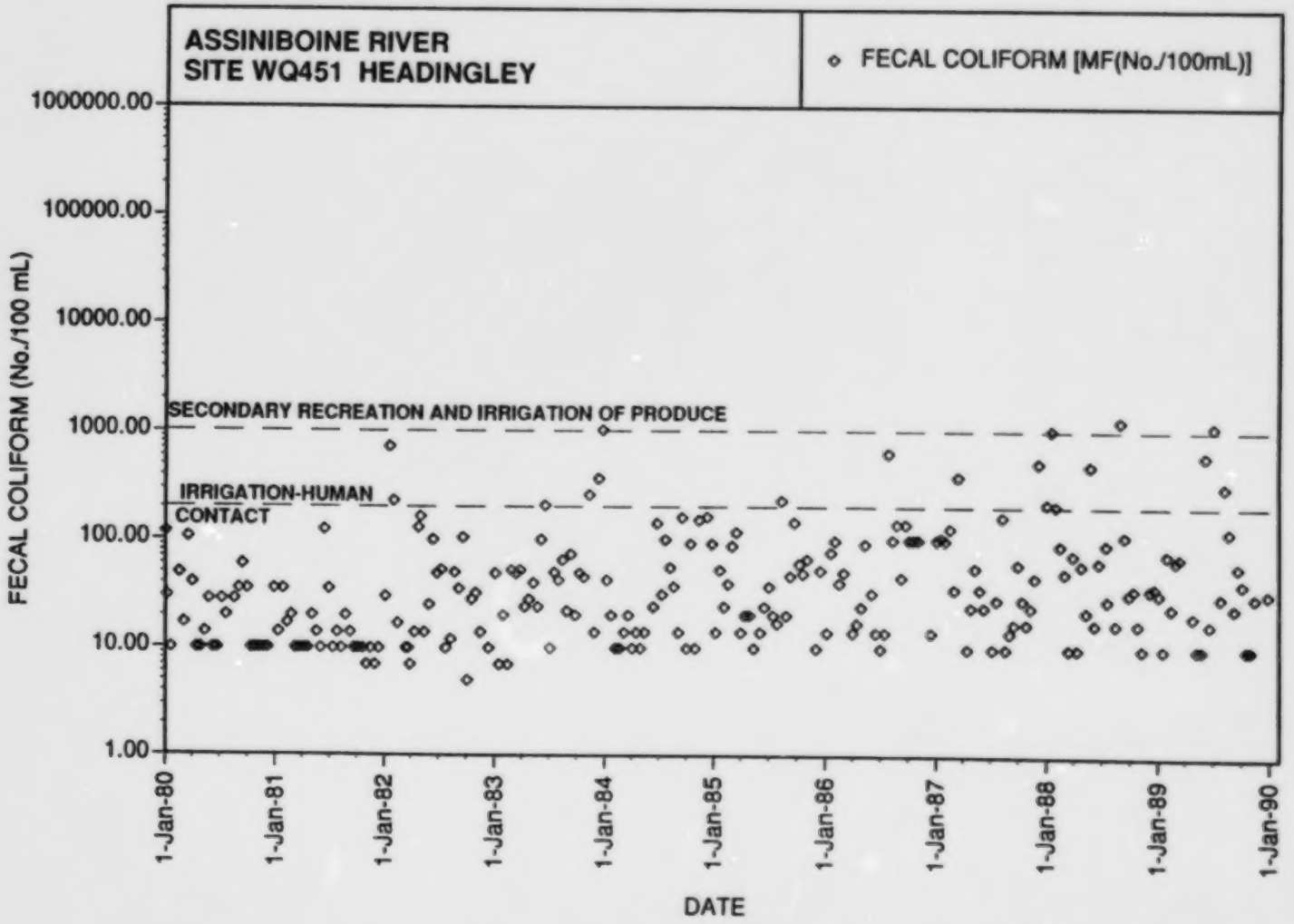


TABLE A1: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact at site WQ451 at Headingley on the Assiniboine River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	34	78	5	1249	167	240	18	7.5%	548
1980	22	30	10	118	28	25	0	0.0%	
1981	14	18	7	124	23	25	0	0.0%	
1982	31	75	5	729	147	25	2	8.0%	481
1983	45	105	7	1032	207	26	4	15.4%	469
1984	31	52	10	163	54	24	0	0.0%	
1985	34	50	10	232	52	24	1	4.2%	232
1986	47	85	10	637	131	22	1	4.5%	637
1987	43	84	10	520	125	23	2	8.7%	454
1988	57	167	10	1249	320	24	5	20.8%	641
1989	41	124	10	1122	261	22	3	13.6%	680
JAN (80-89)	47	128	7	1039	254	22	3	13.6%	662
FEB (80-89)	37	63	7	232	68	18	2	11.1%	221
MARCH (80-89)	34	59	7	387	80	22	1	4.5%	387
APRIL (80-89)	18	24	10	130	26	22	0	0.0%	
MAY (80-89)	27	59	10	490	114	18	1	5.6%	490
JUNE (80-89)	38	79	10	605	132	21	2	9.5%	408
JULY (80-89)	32	108	10	1122	262	22	2	9.1%	880
AUG (80-89)	53	135	10	1249	275	20	3	15.0%	598
SEPT (80-89)	42	58	10	161	47	21	0	0.0%	
OCT (80-89)	24	35	5	100	30	22	0	0.0%	
NOV (80-89)	26	50	7	263	70	16	1	6.3%	263
DEC (80-89)	44	152	7	1032	277	16	3	18.8%	641

TABLE A2: **Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ451 at Headingley on the Assiniboine River.**

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	34	78	5	1249	167	240	4	1.7%	1111
1980	22	30	10	118	28	25	0	0.0%	
1981	14	18	7	124	23	25	0	0.0%	
1982	31	75	5	729	147	25	0	0.0%	
1983	45	105	7	1032	207	26	1	3.8%	1032
1984	31	52	10	163	54	24	0	0.0%	
1985	34	50	10	232	52	24	0	0.0%	
1986	47	85	10	637	131	22	0	0.0%	
1987	43	84	10	520	125	23	0	0.0%	
1988	57	167	10	1249	320	24	2	8.3%	1144
1989	41	124	10	1122	261	22	1	4.5%	1122
JAN (80-89)	47	128	7	1039	254	22	1	4.5%	1039
FEB (80-89)	37	63	7	232	68	18	0	0.0%	
MARCH (80-89)	34	59	7	387	80	22	0	0.0%	
APRIL (80-89)	18	24	10	130	26	22	0	0.0%	
MAY (80-89)	27	59	10	490	114	18	0	0.0%	
JUNE (80-89)	38	79	10	605	132	21	0	0.0%	
JULY (80-89)	32	108	10	1122	262	22	1	4.5%	1122
AUG (80-89)	53	135	10	1249	275	20	1	5.0%	1249
SEPT (80-89)	42	58	10	161	47	21	0	0.0%	
OCT (80-89)	24	35	5	100	30	22	0	0.0%	
NOV (80-89)	26	50	7	263	70	16	0	0.0%	
DEC (80-89)	44	152	7	1032	277	16	1	6.3%	1032

FIGURE A3: Fecal coliform density in the Assiniboine River at site WQ452 at the west perimeter.

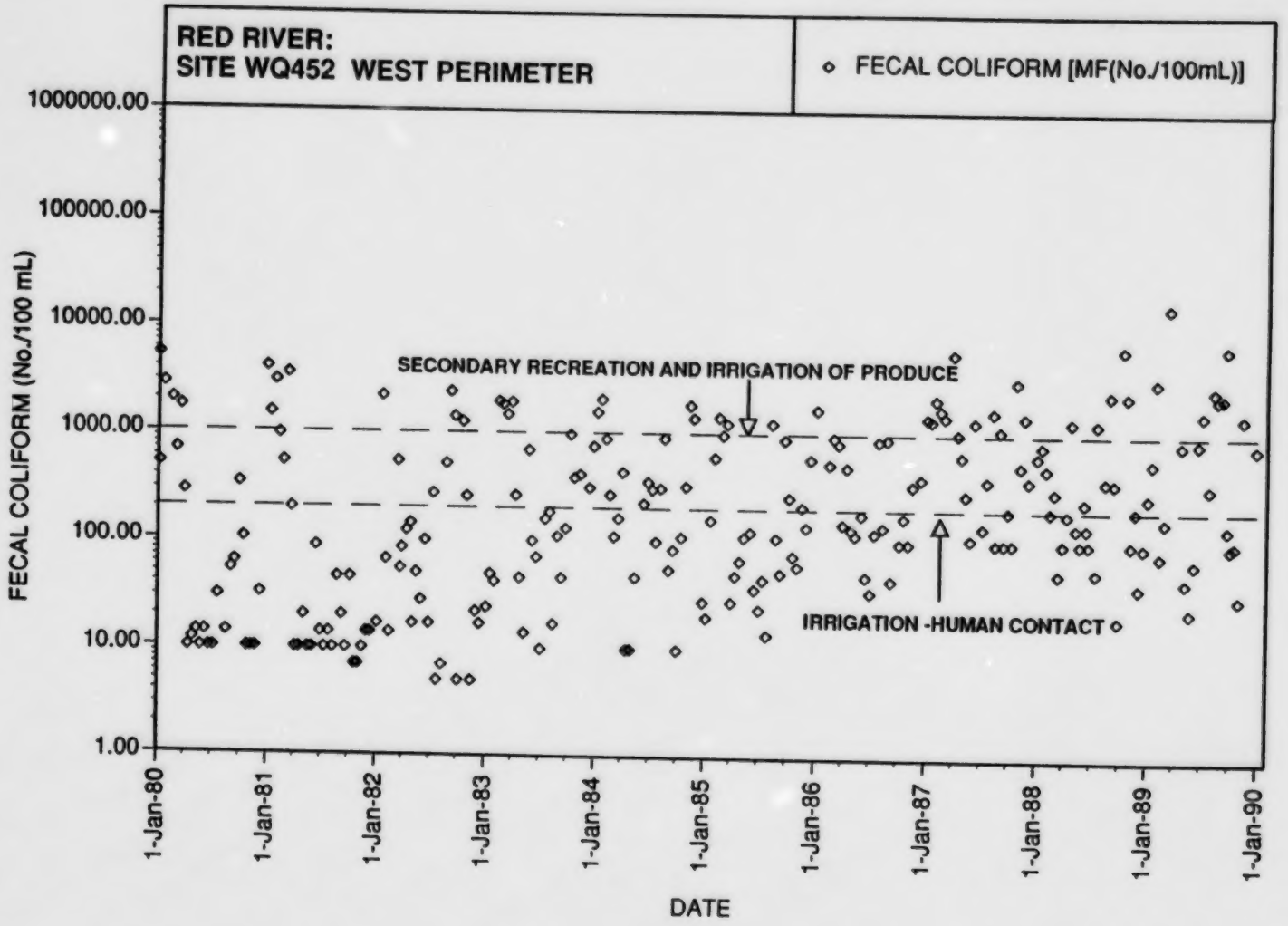


TABLE A3: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, at site WQ452 at the west perimeter on the Assiniboine River.

SITE: WQ452 ASSINIBOINE RIVER AT THE WEST PERIMETER
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	164	676	5	15922	1421	243	108	44.4%	1439
1980	82	721	10	5250	1390	25	9	36.0%	1957
1981	41	404	7	3500	931	25	5	20.0%	1908
1982	74	371	5	2382	672	26	8	30.8%	1108
1983	169	482	10	1960	646	25	11	44.0%	1005
1984	185	487	10	2065	624	24	13	54.2%	844
1985	139	347	14	1441	457	25	9	36.0%	839
1986	231	402	35	1710	434	21	9	42.9%	789
1987	639	1158	100	5691	1269	23	17	73.9%	1523
1988	260	716	20	6417	1335	26	13	50.0%	1329
1989	454	1751	24	15922	3437	23	14	60.9%	2824
JAN (80-89)	587	1389	17	5250	1347	21	16	76.2%	1806
FEB (80-89)	411	824	14	2135	751	17	12	70.6%	1133
MARCH (80-89)	598	1744	53	15922	3357	23	15	65.2%	2612
APRIL (80-89)	107	289	10	1349	373	22	8	36.4%	672
MAY (80-89)	45	101	10	700	165	18	2	11.1%	492
JUNE (80-89)	79	191	10	1342	318	22	5	22.7%	610
JULY (80-89)	77	266	5	1597	434	22	7	31.8%	726
AUG (80-89)	213	700	7	2649	876	20	10	50.0%	1326
SEPT (80-89)	167	763	10	6504	1506	21	7	33.3%	2144
OCT (80-89)	155	746	5	6417	1503	22	9	40.9%	1720
NOV (80-89)	111	428	5	1852	604	20	10	50.0%	821
DEC (80-89)	137	509	14	4000	1005	15	7	46.7%	1037

TABLE A4: **Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ452 at the west perimeter on the Assiniboine River.**

SITE: WQ452 ASSINIBOINE RIVER AT THE WEST PERIMETER
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	164	676	5	15922	1421	243	49	20.2%	2534
1980	82	721	10	5250	1390	25	5	20.0%	3156
1981	41	404	7	3500	931	25	3	12.0%	2676
1982	74	371	5	2382	672	26	4	15.4%	1815
1983	169	482	10	1960	646	25	4	16.0%	1805
1984	185	487	10	2065	624	24	4	16.7%	1727
1985	139	347	14	1441	457	25	3	12.0%	1324
1986	231	402	35	1710	434	21	1	4.8%	1710
1987	639	1158	100	5691	1269	23	12	52.2%	1971
1988	260	716	20	6417	1335	26	5	19.2%	2761
1989	454	1751	24	15922	3437	23	8	34.8%	4480
JAN (80-89)	587	1389	17	5250	1347	21	11	52.4%	2371
FEB (80-89)	411	824	14	2135	751	17	5	29.4%	1854
MARCH (80-89)	598	1744	53	15922	3357	23	9	39.1%	3873
APRIL (80-89)	107	289	10	1349	373	22	2	9.1%	1194
MAY (80-89)	45	101	10	700	165	18	0	0.0%	
JUNE (80-89)	79	191	10	1342	318	22	1	4.5%	1342
JULY (80-89)	77	266	5	1597	434	22	2	9.1%	1447
AUG (80-89)	213	700	7	2649	876	20	5	25.0%	2039
SEPT (80-89)	167	763	10	6504	1506	21	5	23.8%	2746
OCT (80-89)	155	746	5	6417	1503	22	4	18.2%	3293
NOV (80-89)	111	428	5	1852	604	20	4	20.0%	1560
DEC (80-89)	137	509	14	4000	1005	15	1	6.7%	4000

FIGURE A4: Fecal coliform density in the Assiniboine River at site WQ453 at the Main Street Bridge.

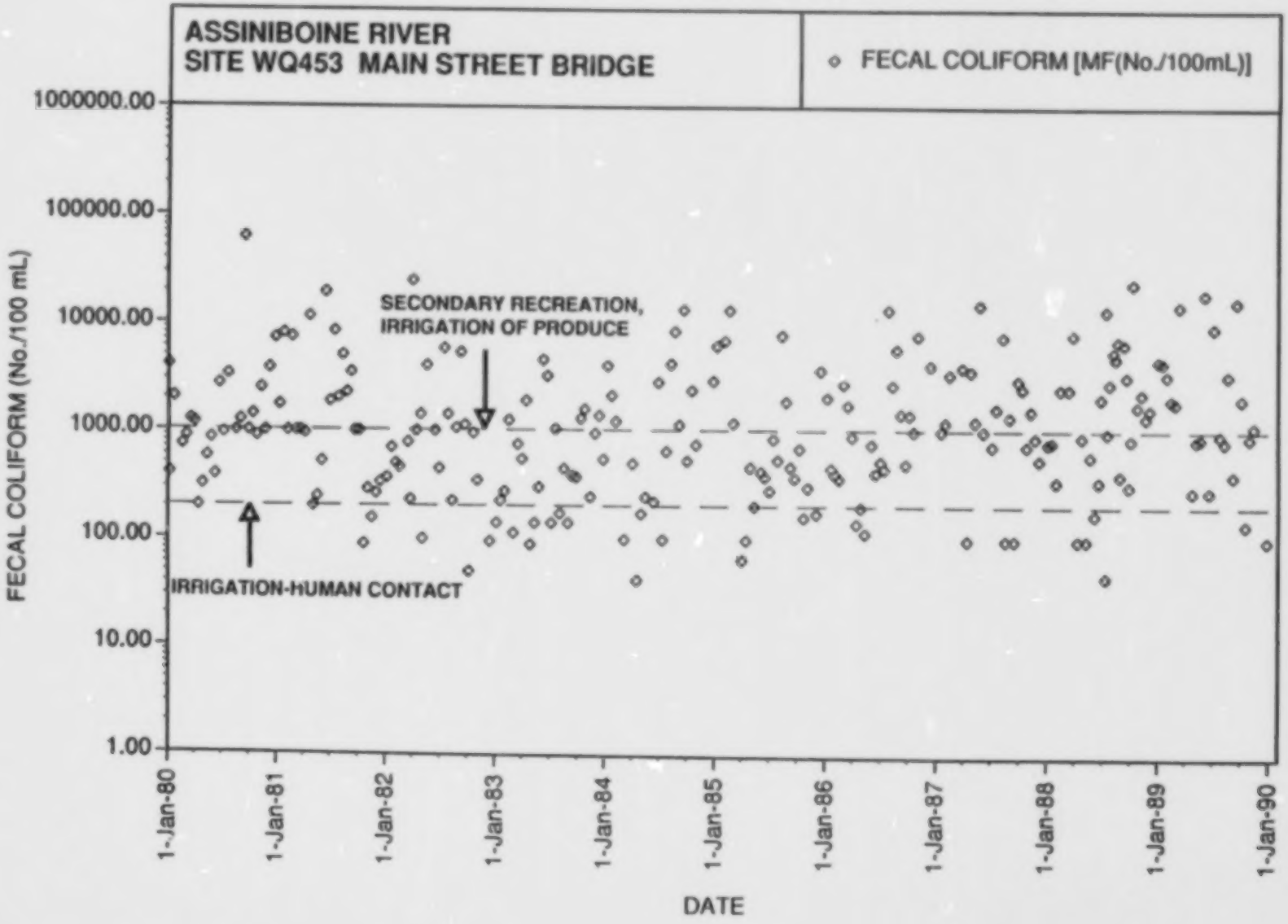


TABLE A5: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, at site WQ453 at the Main Steet Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	986	2659	42	62610	5528	237	203	85.7%	3084
1980	1357	4094	200	62610	12291	25	24	96.0%	4256
1981	1244	3156	89	19365	4587	25	22	88.0%	3566
1982	746	2271	50	24920	5183	23	20	87.0%	2599
1983	476	850	89	4500	1037	26	19	73.1%	1114
1984	864	2292	42	13416	3322	20	16	80.0%	2839
1985	705	2099	65	13276	3415	22	18	81.8%	2538
1986	992	2128	115	13416	3105	23	20	87.0%	2425
1987	1204	2420	100	14967	3353	21	18	85.7%	2807
1988	1255	3183	46	23917	4921	30	26	86.7%	3657
1989	1558	3970	100	19015	5602	22	20	90.9%	4355
JAN (80-89)	1389	2357	141	8000	2205	20	19	95.0%	2474
FEB (80-89)	1253	2529	275	13276	3506	17	17	100.0%	2529
MARCH (80-89)	1340	3582	100	24920	6235	19	17	89.5%	3990
APRIL (80-89)	408	1177	42	11489	2446	22	13	59.1%	1912
MAY (80-89)	436	1431	100	14967	3497	18	12	66.7%	2077
JUNE (80-89)	1045	2943	173	19365	5531	21	20	95.2%	3082
JULY (80-89)	1150	2893	46	13416	4055	24	21	87.5%	3293
AUG (80-89)	1604	3191	100	8398	2836	22	19	86.4%	3674
SEPT (80-89)	1503	5632	100	62610	13408	22	21	95.5%	5895
OCT (80-89)	857	2045	50	23917	4815	23	19	82.6%	2452
NOV (80-89)	848	1427	155	7630	1852	15	14	93.3%	1517
DEC (80-89)	856	1899	95	7211	2127	14	11	78.6%	2383

TABLE A8: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ453 at the Main Street Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000. (No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	986	2659	42	62610	5528	237	106	44.7%	5352
1980	1357	4094	200	62610	12291	25	12	48.0%	7764
1981	1244	3156	89	19365	4587	25	11	44.0%	6441
1982	746	2271	50	24920	5183	23	8	34.8%	5623
1983	476	850	89	4500	1037	26	8	30.8%	2015
1984	864	2292	42	13416	3322	20	10	50.0%	4253
1985	705	2099	65	13276	3415	22	7	31.8%	5816
1986	992	2128	115	13416	3105	23	10	43.5%	4274
1987	1204	2420	100	14967	3353	21	12	57.1%	3803
1988	1255	3183	46	23917	4921	30	16	53.3%	5548
1989	1558	3970	100	19015	5602	22	12	54.5%	6815
JAN (80-89)	1389	2357	141	8000	2205	20	11	55.0%	3844
FEB (80-89)	1253	2529	275	13276	3506	17	9	52.9%	4324
MARCH (80-89)	1340	3582	100	24920	6235	19	10	52.6%	6265
APRIL (80-89)	408	1177	42	11489	2446	22	5	22.7%	3913
MAY (80-89)	436	1431	100	14967	3497	18	3	16.7%	6735
JUNE (80-89)	1045	2943	173	19365	5531	21	8	38.1%	6932
JULY (80-89)	1150	2893	46	13416	4055	24	11	45.8%	5660
AUG (80-89)	1604	3191	100	8398	2836	22	14	63.6%	4780
SEPT (80-89)	1503	5632	100	62610	13400	22	13	59.1%	9229
OCT (80-89)	857	2045	50	23917	4815	23	9	39.1%	4245
NOV (80-89)	848	1427	155	7630	1852	15	6	40.0%	2723
DEC (80-89)	856	1899	95	7211	2127	14	7	50.0%	3502

FIGURE A5: Fecal coliform density in the Red River at site WQ367 at the south gate of the Floodway.

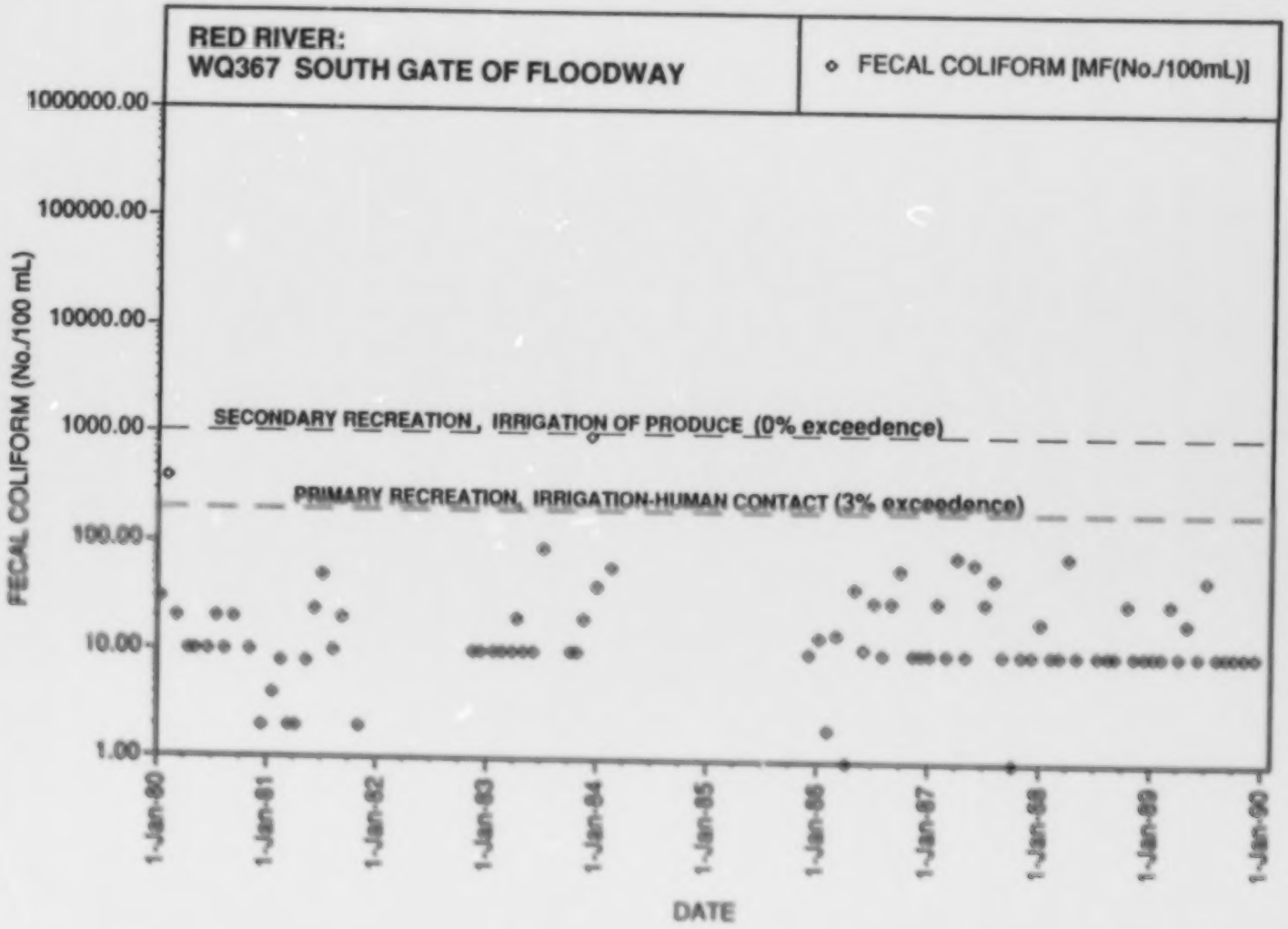


FIGURE A6: Fecal coliform density in the Red River at site WQ445 at the south Floodway control.

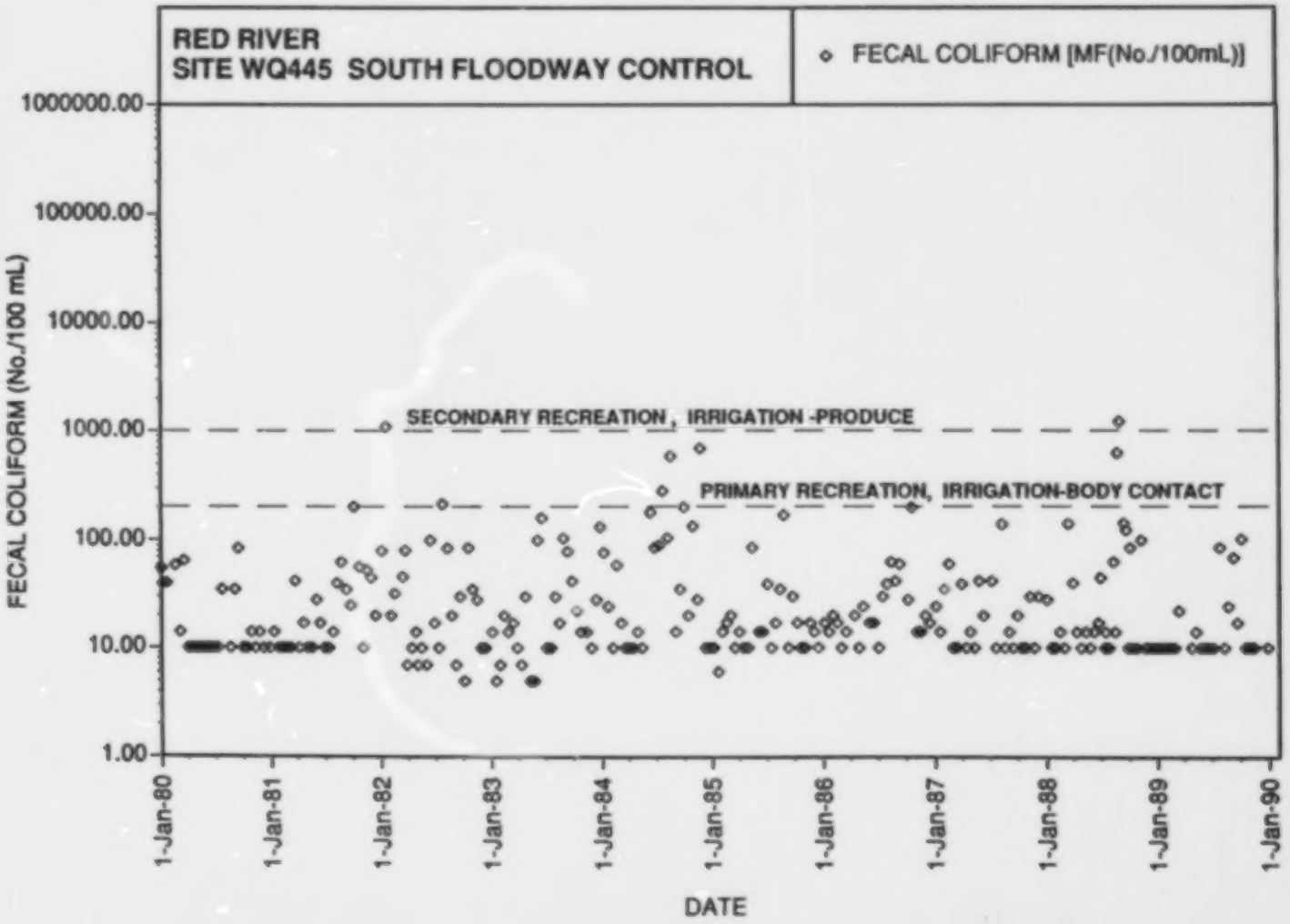


TABLE A7: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQ445 at the south floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	22	49	5	1220	127	253	8	3.2%	617
1980	17	24	10	84	22	25	0	0.0%	
1981	21	31	10	203	40	25	1	4.0%	203
1982	26	80	5	1100	213	26	2	7.7%	657
1983	20	35	5	160	43	26	0	0.0%	
1984	42	109	10	698	176	25	3	12.0%	522
1985	17	24	6	169	34	25	0	0.0%	
1986	22	31	10	200	40	23	0	0.0%	
1987	19	26	10	140	28	24	0	0.0%	
1988	25	89	10	1220	235	32	2	6.3%	925
1989	15	22	10	102	27	22	0	0.0%	
JAN (80-89)	22	76	5	1100	236	21	1	4.8%	1100
FEB (80-89)	18	23	7	60	18	19	0	0.0%	
MARCH (80-89)	19	28	7	141	31	24	0	0.0%	
APRIL (80-89)	12	12	7	30	5	21	0	0.0%	
MAY (80-89)	12	17	5	85	19	18	0	0.0%	
JUNE (80-89)	24	41	7	179	51	22	0	0.0%	
JULY (80-89)	22	43	10	283	68	24	2	8.3%	249
AUG (80-89)	57	158	10	1220	291	22	3	13.6%	812
SEPT (80-89)	30	43	7	144	38	21	0	0.0%	
OCT (80-89)	27	55	5	203	68	23	1	4.3%	203
NOV (80-89)	20	54	10	698	149	21	1	4.8%	698
DEC (80-89)	17	23	10	133	30	17	0	0.0%	

TABLE A8: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	22	49	5	1220	127	253	2	0.8%	1160
1980	17	24	10	84	22	25	0	0.0%	
1981	21	31	10	203	40	25	0	0.0%	
1982	26	80	5	1100	213	26	1	3.8%	1100
1983	20	35	5	160	43	26	0	0.0%	
1984	42	109	10	698	176	25	0	0.0%	
1985	17	24	6	169	34	25	0	0.0%	
1986	22	31	10	200	40	23	0	0.0%	
1987	19	26	10	140	28	24	0	0.0%	
1988	25	89	10	1220	235	32	1	3.1%	1220
1989	15	22	10	102	27	22	0	0.0%	
JAN (80-89)	22	76	5	1100	236	21	1	4.8%	1100
FEB (80-89)	18	23	7	60	18	19	0	0.0%	
MARCH (80-89)	19	28	7	141	31	24	0	0.0%	
APRIL (80-89)	12	12	7	30	5	21	0	0.0%	
MAY (80-89)	12	17	5	85	19	18	0	0.0%	
JUNE (80-89)	24	41	7	179	51	22	0	0.0%	
JULY (80-89)	22	43	10	283	68	24	0	0.0%	
AUG (80-89)	57	158	10	1220	291	22	1	4.5%	1220
SEPT (80-89)	30	43	7	144	38	21	0	0.0%	
OCT (80-89)	27	55	5	203	68	23	0	0.0%	
NOV (80-89)	20	54	10	698	149	21	0	0.0%	
DEC (80-89)	17	23	10	133	30	17	0	0.0%	

FIGURE A7: Fecal coliform density in the Red River at site WQ576 at the Fort Gary Bridge.

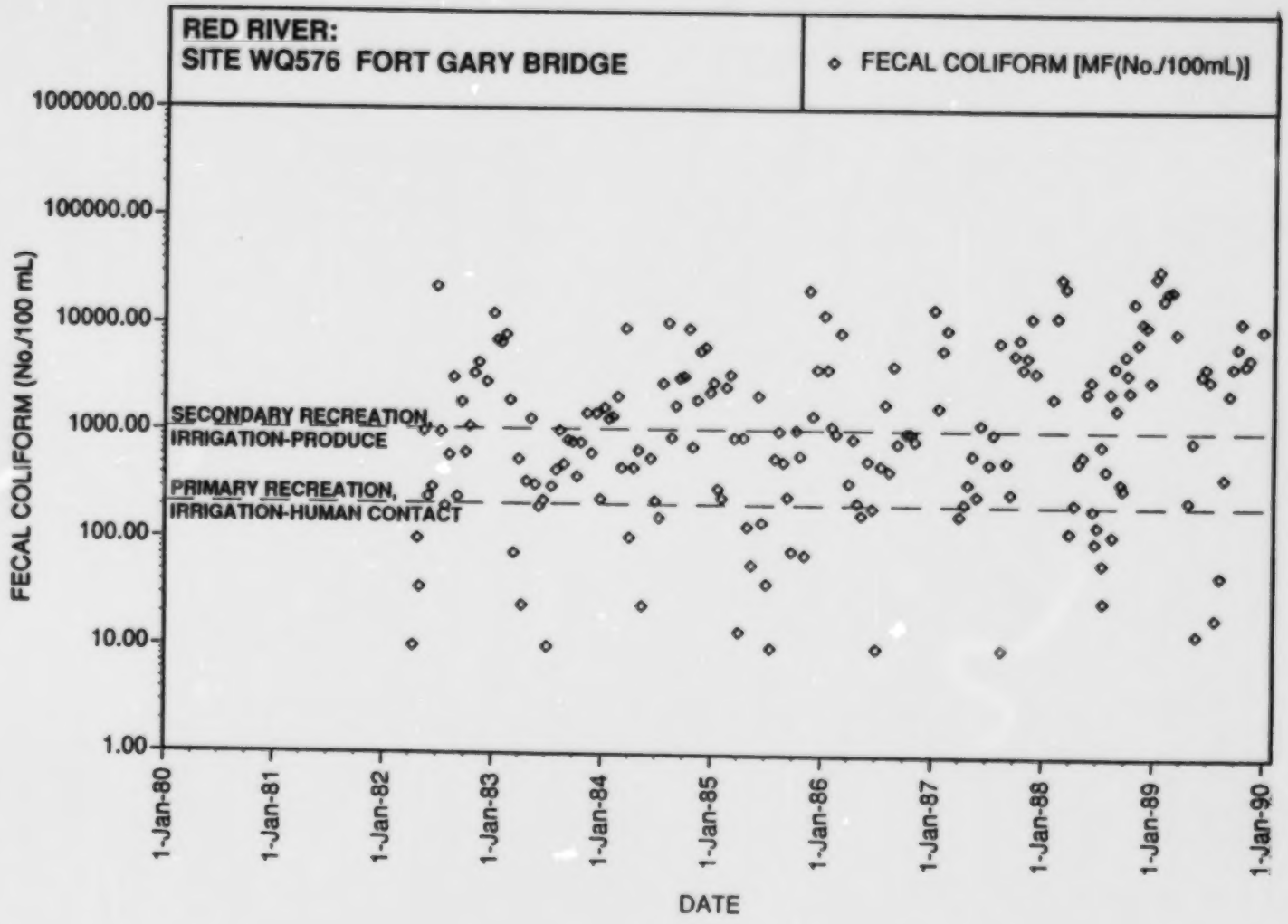


TABLE A9: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQ576 at Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT.
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	989	3510	10	34409	5855	189	155	82.0%	4261
1980									
1981									
1982	745	2956	10	22361	5532	19	15	78.9%	3721
1983	641	1429	10	8005	2261	25	21	84.0%	1686
1984	1250	2690	24	10541	3087	25	22	88.0%	3044
1985	432	1793	10	21399	4241	25	17	68.0%	2604
1986	782	2010	10	12538	3194	20	17	85.0%	2342
1987	1361	3733	10	14491	4238	22	20	90.9%	4098
1988	1262	4693	28	28340	7122	31	24	77.4%	6029
1989	2544	8708	14	34409	10070	22	19	86.4%	10079
JAN (82-89)	5471	10829	300	34409	11062	13	13	100.0%	10829
FEB (82-89)	3199	5743	245	21549	6072	13	13	100.0%	5743
MARCH (82-89)	2066	7749	74	28340	9859	14	11	78.6%	9829
APRIL (82-89)	166	302	10	896	269	17	11	64.7%	432
MAY (82-89)	263	604	14	2449	669	14	9	64.3%	906
JUNE (82-89)	620	2217	100	22361	5202	18	12	66.7%	3243
JULY (82-89)	202	682	10	3250	933	20	11	55.0%	1190
AUG (82-89)	793	2079	10	10541	2779	19	16	84.2%	2458
SEPT (82-89)	894	1709	79	5548	1850	17	16	94.1%	1811
OCT (82-89)	2173	4057	385	17277	4681	18	18	100.0%	4057
NOV (82-89)	3119	5695	73	21399	5613	15	14	93.3%	6097
DEC (82-89)	2839	4118	239	10361	3287	11	11	100.0%	4118

TABLE A10: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ576 at the Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE; 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	989	3510	10	34409	5855	189	91	48.1%	6872
1980									
1981									
1982	745	2956	10	22361	5532	19	8	42.1%	6475
1983	641	1429	10	8005	2261	25	8	32.0%	3626
1984	1250	2690	24	10541	3087	25	15	60.0%	4194
1985	432	1793	10	21399	4241	25	9	36.0%	4439
1986	782	2010	10	12538	3194	20	6	30.0%	5372
1987	1361	3733	10	14491	4238	22	12	54.5%	6511
1988	1262	4693	28	28340	7122	31	17	54.8%	8315
1989	2544	8708	14	34409	10070	22	16	72.7%	11874
JAN (82-89)	5471	10829	300	34409	11062	13	12	92.3%	11707
FEB (82-89)	3199	5743	245	21549	6072	13	11	84.6%	6675
MARCH (82-89)	2066	7749	74	28340	9859	14	8	57.1%	13275
APRIL (82-89)	166	302	10	896	269	17	0	0.0%	
MAY (82-89)	263	604	14	2449	669	14	2	14.3%	1875
JUNE (82-89)	620	2217	100	22361	5202	18	6	33.3%	6130
JULY (82-89)	202	682	10	3250	933	20	3	15.0%	2641
AUG (82-89)	793	2079	10	10541	2779	19	9	47.4%	3944
SEPT (82-89)	894	1709	79	5548	1850	17	7	41.2%	3504
OCT (82-89)	2173	4057	385	17277	4681	18	11	61.1%	6169
NOV (82-89)	3119	5695	73	21399	5613	15	12	80.0%	6989
DEC (82-89)	2839	4118	239	10361	3287	11	10	90.9%	4506

FIGURE A8: Fecal coliform density in the Red River at site WQ447 at the Norwood Bridge.

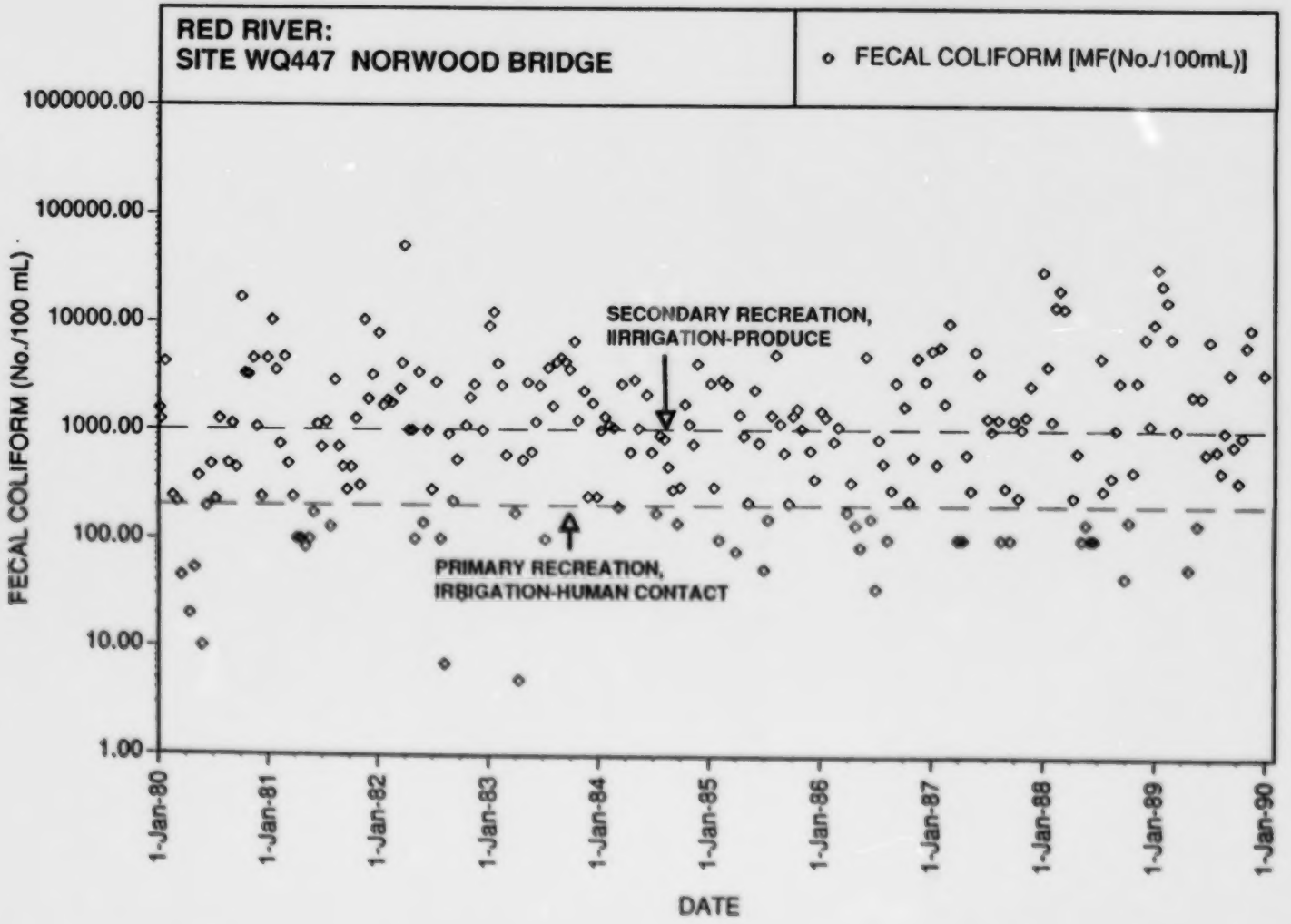


TABLE A11: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQWQ447 at Norwood Bridge on the Red River.

SITE: WQ447 RED RIVER AT THE NORWOOD BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	866	2634	5	50912	5355	232	188	81.0%	3226
1980	549	1933	10	16852	3531	24	19	79.2%	2424
1981	690	1844	85	10488	2878	25	19	76.0%	2390
1982	838	3569	7	50912	10016	25	20	80.0%	4443
1983	1308	2896	5	12490	3036	25	22	88.0%	3278
1984	812	1170	141	4195	1022	22	19	86.4%	1328
1985	674	1224	53	5050	1233	23	19	82.6%	1462
1986	576	1196	35	4920	1465	21	15	71.4%	1628
1987	874	2016	100	9939	2559	22	18	81.8%	2441
1988	1011	4602	45	30000	7753	23	17	73.9%	6189
1989	2033	5804	55	32570	8299	22	20	90.9%	6375
JAN (80-89)	3656	7719	300	32570	9542	21	21	100.0%	7719
FEB (80-89)	1905	3643	100	16037	4501	18	17	94.4%	3852
MARCH (80-89)	1321	6219	45	50912	12121	19	15	78.9%	7842
APRIL (80-89)	196	404	5	1396	409	20	10	50.0%	726
MAY (80-89)	353	1120	10	5496	1582	18	10	55.6%	1940
JUNE (80-89)	655	1202	100	4920	1283	21	15	71.4%	1626
JULY (80-89)	533	1300	35	6928	1772	22	15	68.2%	1857
AUG (80-89)	666	1393	7	5050	1573	20	17	85.0%	1627
SEPT (80-89)	587	1198	45	4390	1394	20	17	85.0%	1393
OCT (80-89)	888	2065	30	16852	3621	22	20	90.9%	2263
NOV (80-89)	1991	3167	245	10488	2927	18	18	100.0%	3167
DEC (80-89)	1369	2216	245	7243	2054	13	13	100.0%	2216

TABLE A12: **Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ447 at the Norwood Bridge on the Red River.**

SITE: WQ447 RED RIVER AT THE NORWOOD BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	866	2634	5	50912	5355	232	116	50.0%	4899
1980	549	1933	10	16852	3531	24	11	45.8%	3939
1981	690	1844	85	10488	2878	25	10	40.0%	4101
1982	838	3569	7	50912	10016	25	12	48.0%	6909
1983	1308	2896	5	12490	3036	25	17	68.0%	4111
1984	812	1170	141	4195	1022	22	10	45.5%	1944
1985	674	1224	53	5050	1233	23	11	47.8%	2159
1986	576	1196	35	4920	1465	21	8	38.1%	2614
1987	874	2016	100	9939	2559	22	12	54.5%	3419
1988	1011	4602	45	30000	7753	23	12	52.2%	8605
1989	2033	5804	55	32570	8299	22	13	59.1%	9444
JAN (80-89)	3656	7719	300	32570	9542	21	18	85.7%	8906
FEB (80-89)	1905	3643	100	16037	4501	18	14	77.8%	4550
MARCH (80-89)	1321	6219	45	50912	12121	19	11	57.9%	10554
APRIL (80-89)	196	404	5	1396	409	20	1	5.0%	1396
MAY (80-89)	353	1120	10	5496	1582	18	6	33.3%	2981
JUNE (80-89)	655	1202	100	4920	1283	21	8	38.1%	2486
JULY (80-89)	533	1300	35	6928	1772	22	8	36.4%	2932
AUG (80-89)	666	1393	7	5050	1573	20	8	40.0%	2770
SEPT (80-89)	587	1198	45	4390	1394	20	7	35.0%	2796
OCT (80-89)	888	2065	30	16852	3621	22	13	59.1%	3258
NOV (80-89)	1991	3167	245	10488	2927	18	14	77.8%	3939
DEC (80-89)	1369	2216	245	7243	2054	13	8	61.5%	3290

FIGURE A9: Fecal coliform density in the Red River at site WQ448 at the Redwood Bridge.

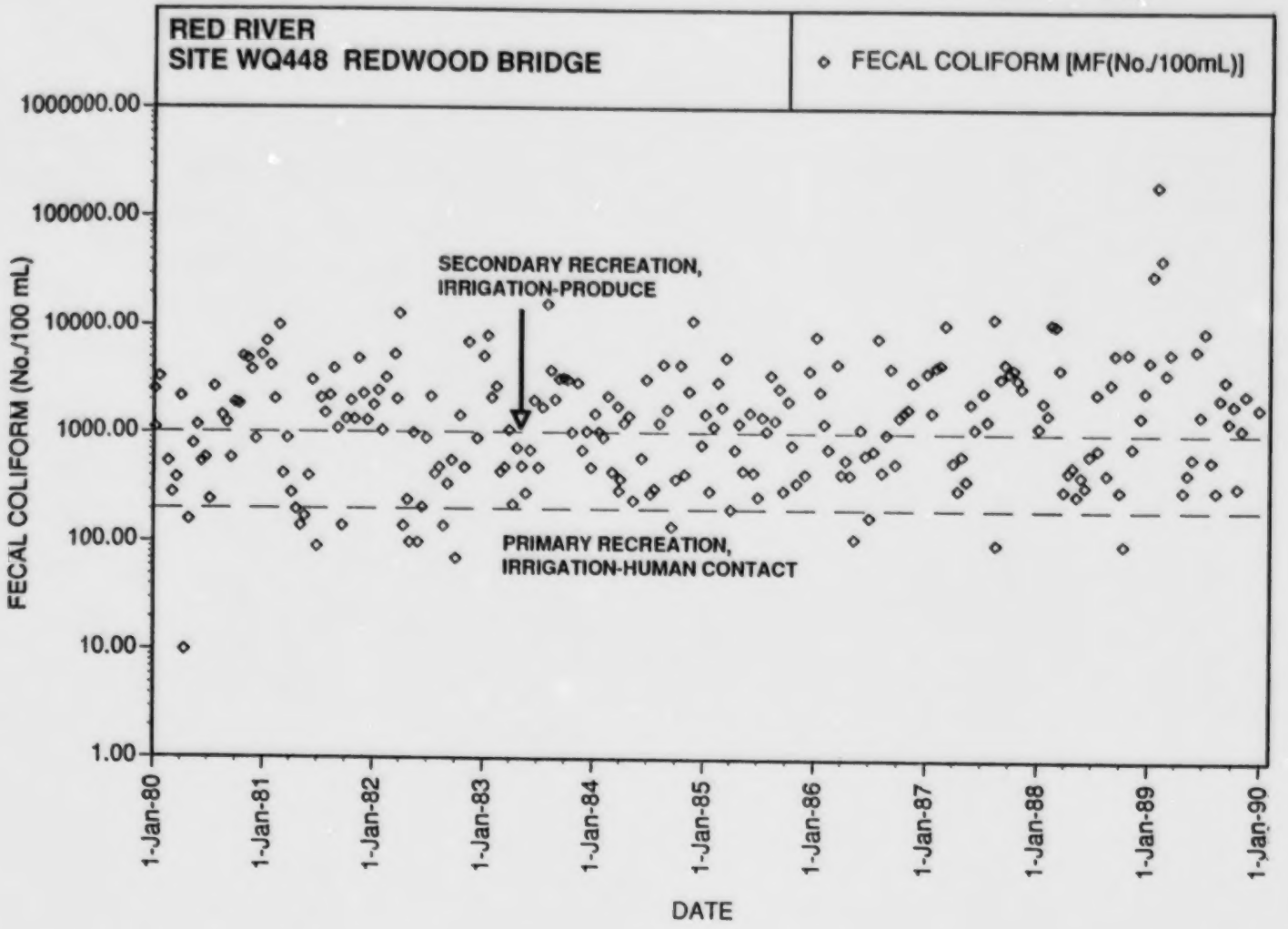


TABLE A13: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQ448 at Redwood Bridge on the Red River.

SITE: WQ448 RED RIVER AT THE REDWOOD BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	1206	3221	10	201960	13504	240	223	92.9%	3457
1980	981	1737	10	5244	1602	25	23	92.0%	1880
1981	1086	2123	91	10000	2380	25	20	80.0%	2616
1982	740	1818	71	12845	2849	25	20	80.0%	2244
1983	1398	2455	224	15716	3244	26	26	100.0%	2455
1984	988	1652	141	11049	2248	26	25	96.2%	1713
1985	1006	1470	205	5062	1285	24	24	100.0%	1470
1986	1190	1937	110	7997	2255	22	20	90.9%	2117
1987	1922	3186	100	12000	3066	21	20	95.2%	3340
1988	1146	2341	100	10688	2999	24	23	95.8%	2439
1989	2603	14698	316	201960	43106	22	22	100.0%	14698
JAN (80-89)	3400	14021	300	201960	43534	21	21	100.0%	14021
FEB (80-89)	2499	5072	548	42596	9514	19	19	100.0%	5072
MARCH (80-89)	1543	3186	283	12845	3696	23	23	100.0%	3186
APRIL (80-89)	360	524	10	2159	473	23	19	82.6%	607
MAY (80-89)	418	586	100	1936	506	18	14	77.8%	716
JUNE (80-89)	749	1242	91	6274	1438	21	19	90.5%	1363
JULY (80-89)	1028	1819	175	9165	2305	22	21	95.5%	1898
AUG (80-89)	1433	2982	100	15716	3998	20	18	90.0%	3300
SEPT (80-89)	1194	1992	141	5632	1686	21	19	90.5%	2187
OCT (80-89)	1272	2007	71	5786	1617	22	20	90.9%	2200
NOV (80-89)	2077	3035	359	11049	2742	17	17	100.0%	3035
DEC (80-89)	1363	1771	433	5244	1413	13	13	100.0%	1771

TABLE A14: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ448 at the Redwood Bridge on the Red River.

SITE: WQ448 RED RIVER AT THE REDWOOD BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	1206	3221	10	201960	13504	240	138	57.5%	5277
1980	981	1737	10	5244	1602	25	14	56.0%	2741
1981	1086	2123	91	10000	2380	25	16	64.0%	3145
1982	740	1818	71	12845	2849	25	10	40.0%	3932
1983	1398	2455	224	15716	3244	26	16	61.5%	3673
1984	988	1652	141	11049	2248	26	13	50.0%	2872
1985	1006	1470	205	5062	1285	24	14	58.3%	2214
1986	1190	1937	110	7997	2255	22	11	50.0%	3346
1987	1922	3186	100	12000	3066	21	16	76.2%	4056
1988	1146	2341	100	10688	2999	24	12	50.0%	4231
1989	2603	14698	316	201960	43106	22	16	72.7%	20043
JAN (80-89)	3400	14021	300	201960	43534	21	20	95.2%	14767
FEB (80-89)	2499	5072	548	42596	9514	19	16	84.2%	5886
MARCH (80-89)	1543	3186	283	12845	3696	23	13	56.5%	5287
APRIL (80-89)	360	524	10	2159	473	23	3	13.0%	1548
MAY (80-89)	418	586	100	1936	506	18	3	16.7%	1518
JUNE (80-89)	749	1242	91	6274	1438	21	8	38.1%	2481
JULY (80-89)	1028	1819	175	9165	2305	22	12	54.5%	2981
AUG (80-89)	1433	2982	100	15716	3998	20	13	65.0%	4361
SEPT (80-89)	1194	1992	141	5632	1686	21	13	61.9%	2991
OCT (80-89)	1272	2007	71	5786	1617	22	16	72.7%	2627
NOV (80-89)	2077	3035	359	11049	2742	17	13	76.5%	3790
DEC (80-89)	1363	1771	433	5244	1413	13	8	61.5%	2441

FIGURE A10: Fecal coliform density in the Red River at site WQ449 at the north perimeter.

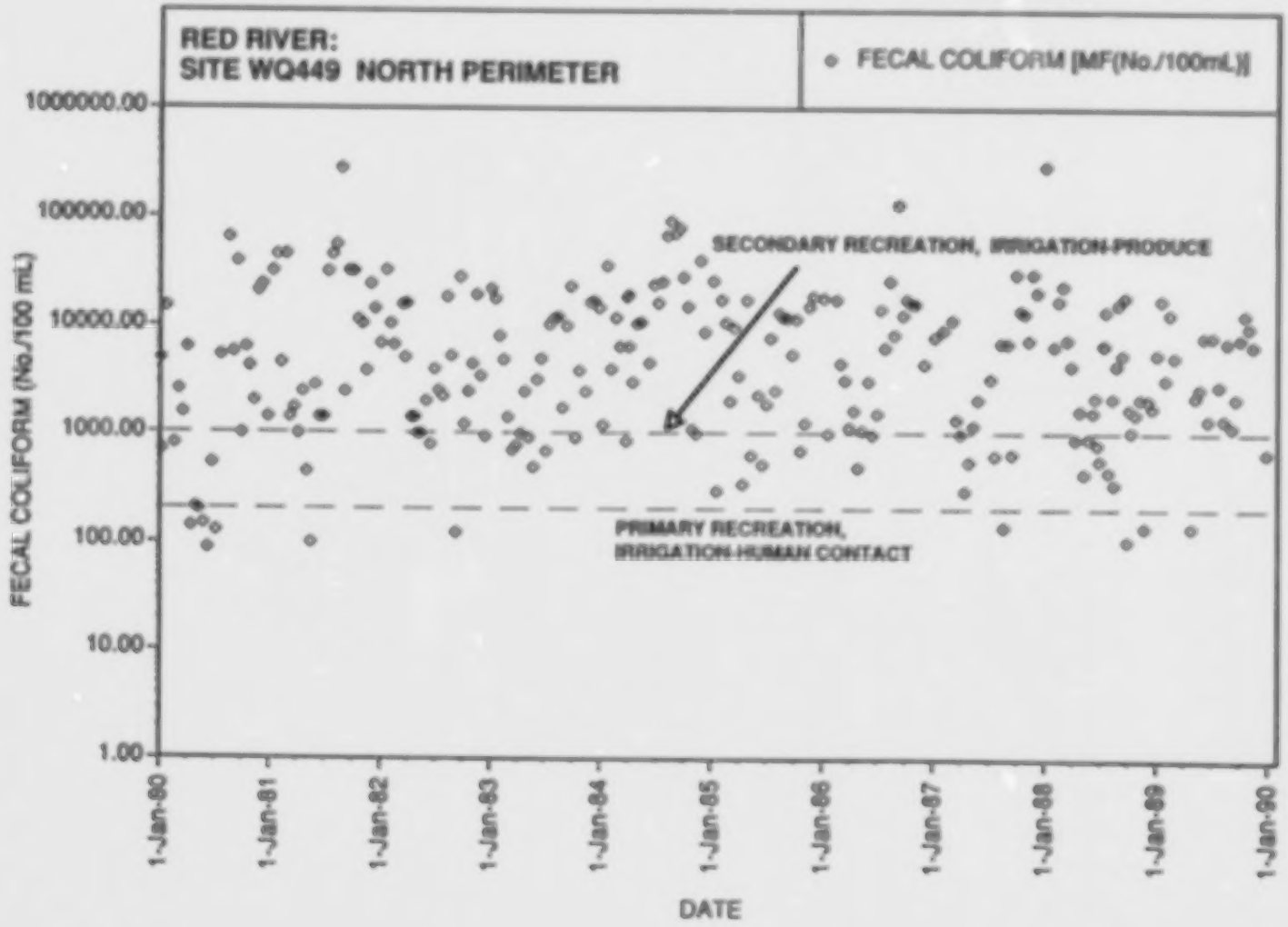


TABLE A15: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	4144	12620	88	300000	29795	248	237	95.6%	13200
1980	1942	8306	88	64498	14984	25	20	80.0%	10347
1981	7328	27524	100	284956	56519	25	24	96.0%	28666
1982	3656	7458	124	32404	8837	26	25	96.2%	7752
1983	3952	7493	490	23238	7304	26	26	100.0%	7493
1984	12668	23187	849	91499	26072	26	26	100.0%	23187
1985	4095	8059	300	26115	7362	24	24	100.0%	8059
1986	5610	13985	490	131590	27336	22	22	100.0%	13985
1987	3346	8031	141	30000	9177	21	20	95.2%	8425
1988	2565	14155	105	300000	52521	32	30	93.8%	15090
1989	3607	5702	141	17417	4703	21	20	95.2%	5880
JAN (80-89)	5183	29656	300	300000	65003	20	20	100.0%	29656
FEB (80-89)	4077	11808	800	45497	10289	16	16	100.0%	11808
MARCH (80-89)	3811	6115	707	23474	6448	24	24	100.0%	6115
APRIL (80-89)	1495	3182	141	19442	5106	23	21	91.3%	3471
MAY (80-89)	932	2052	100	10954	3235	18	15	83.3%	2433
JUNE (80-89)	1725	3241	88	24000	5002	22	21	95.5%	3391
JULY (80-89)	1153	9015	129	44956	11045	24	23	95.8%	9401
AUG (80-89)	2141	32391	141	284956	61926	22	21	95.5%	33927
SEPT (80-89)	2179	23515	105	131590	32446	22	20	90.9%	25855
OCT (80-89)	2186	8943	693	31859	8814	23	23	100.0%	8943
NOV (80-89)	3911	10663	141	40000	10687	20	19	95.0%	11217
DEC (80-89)	3215	11023	671	24372	9101	14	14	100.0%	11023

TABLE A16: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	4144	12620	88	300000	29795	248	196	79.0%	15813
1980	1942	8306	88	64498	14984	25	15	60.0%	13580
1981	7328	27524	100	284956	56519	25	22	88.0%	31207
1982	3656	7458	124	32404	8837	26	21	80.8%	9050
1983	3952	7493	490	23238	7304	26	19	73.1%	9963
1984	12668	23187	849	91499	26072	26	24	92.3%	25043
1985	4095	8059	300	26115	7362	24	19	79.2%	10048
1986	5610	13985	490	131590	27336	22	19	86.4%	16063
1987	3346	8031	141	30000	9177	21	15	71.4%	11025
1988	2565	14155	105	300000	52521	32	23	71.9%	19492
1989	3607	5702	141	17417	4703	21	19	90.5%	6260
JAN (80-89)	5163	29656	300	300000	65003	20	17	85.0%	34771
FEB (80-89)	4077	11808	800	45497	10289	16	15	93.8%	12542
MARCH (80-89)	3811	6115	707	23474	6448	24	20	83.3%	7171
APRIL (80-89)	1495	3182	141	19442	5106	23	13	56.5%	5239
MAY (80-89)	932	2052	100	10954	3235	18	7	38.9%	4382
JUNE (80-89)	1725	3241	88	24000	5002	22	15	68.2%	4467
JULY (80-89)	1153	9015	129	44956	11045	24	20	83.3%	10723
AUG (80-89)	2141	32391	141	284956	61926	22	20	90.9%	35606
SEPT (80-89)	2179	23515	105	131590	32446	22	19	86.4%	27182
OCT (80-89)	2186	8943	693	31859	8814	23	20	87.0%	10153
NOV (80-89)	3911	10663	141	40000	10687	20	18	90.0%	11785
DEC (80-89)	3215	11023	671	24372	9101	14	12	85.7%	12725

FIGURE A11: Fecal coliform density in the Red River at sitw WQ450 at the Lockport Bridge.

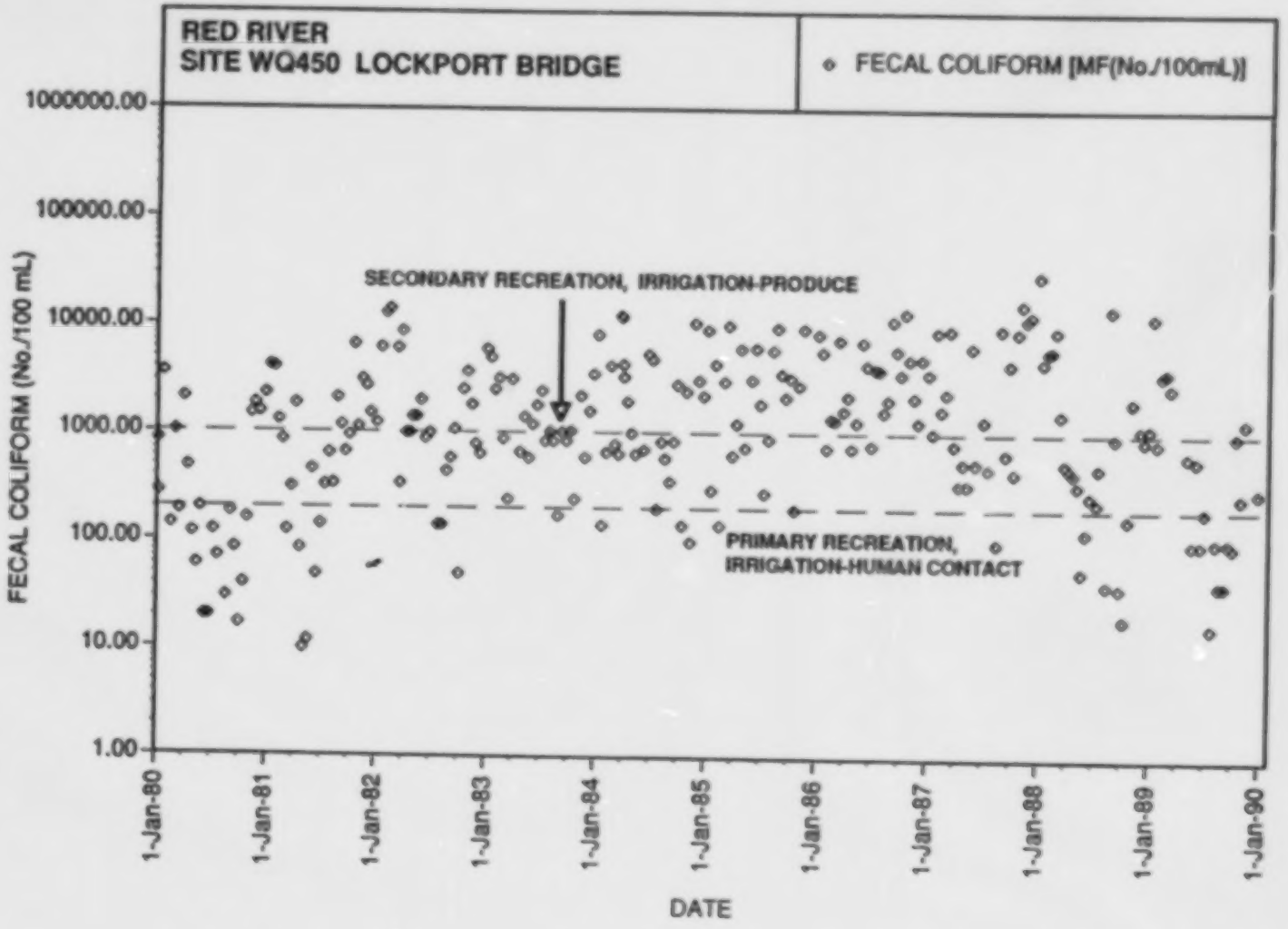


TABLE A17: Summary statistics and exceedence of the fecal coliform objective for irrigation water-human contact, and primary recreation, at site WQ450 at the Lockport Bridge on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: PRIMARY RECREATION, IRRIGATION-HUMAN CONTACT
OBJECTIVE: 200.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	953	2667	10	30000	3764	244	197	80.7%	3279
1980	224	679	17	3600	945	25	10	40.0%	1553
1981	559	1385	10	6600	1625	25	19	76.0%	1801
1982	1245	2823	50	14283	3897	25	22	88.0%	3193
1983	1203	1720	173	5945	1477	25	24	96.0%	1784
1984	1155	3049	100	12394	3606	28	24	85.7%	3532
1985	2257	3991	141	10159	3354	25	23	92.0%	4323
1986	2702	3852	748	13382	3379	23	23	100.0%	3852
1987	1939	4443	100	16180	4877	23	22	95.7%	4640
1988	681	3334	20	30000	6697	24	18	75.0%	4421
1989	375	1405	17	12442	2775	21	12	57.1%	2391
JAN (80-89)	2379	5163	141	30000	6921	19	18	94.7%	5442
FEB (80-89)	2217	4077	141	14283	4092	19	17	89.5%	4540
MARCH (80-89)	1781	3811	125	12394	4068	26	24	92.3%	4115
APRIL (80-89)	925	1495	85	6150	1518	21	19	90.5%	1641
MAY (80-89)	342	932	10	6481	1477	18	12	66.7%	1362
JUNE (80-89)	586	1725	20	7130	2206	21	15	71.4%	2385
JULY (80-89)	514	1152	17	4791	1440	21	15	71.4%	1563
AUG (80-89)	527	2141	30	14588	3862	19	12	63.2%	3337
SEPT (80-89)	778	2179	39	11396	3168	21	16	76.2%	2832
OCT (80-89)	530	2186	17	13382	3402	22	13	59.1%	3630
NOV (80-89)	2103	3911	100	16180	4443	20	19	95.0%	4111
DEC (80-89)	2150	3215	300	12638	3211	17	17	100.0%	3215

TABLE A18: Summary statistics and exceedence of the fecal coliform objective for secondary recreation, and irrigation of produce, at site WQ450 at the Lockport Bridge on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000.(No./100mL)

SAMPLE PERIOD	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	953	2667	10	30000	3764	244	127	52.0%	4744
1980	224	679	17	3600	945	25	7	28.0%	1987
1981	559	1385	10	6600	1625	25	11	44.0%	2695
1982	1245	2823	50	14283	3897	25	13	52.0%	4886
1983	1203	1720	173	5945	1477	25	15	60.0%	2469
1984	1155	3049	100	12394	3606	28	14	50.0%	5548
1985	2257	3991	141	10159	3354	25	18	72.0%	5366
1986	2702	3852	748	13382	3379	23	20	87.0%	4315
1987	1939	4443	100	16180	4877	23	14	60.9%	6991
1988	681	3334	20	30000	6697	24	9	37.5%	8321
1989	375	1405	17	12442	2775	21	6	28.6%	4174
JAN (80-89)	2379	5163	141	30000	6921	19	14	73.7%	6833
FEB (80-89)	2217	4077	141	14283	4092	19	14	73.7%	5350
MARCH (80-89)	1781	3811	125	12394	4068	26	16	61.5%	5886
APRIL (80-89)	925	1495	85	6150	1518	21	9	42.9%	2758
MAY (80-89)	342	932	10	6481	1477	18	5	27.8%	2403
JUNE (80-89)	586	1725	20	7130	2206	21	8	38.1%	3911
JULY (80-89)	514	1152	17	4791	1440	21	6	28.6%	3071
AUG (80-89)	527	2141	30	14588	3862	19	7	36.8%	5283
SEPT (80-89)	778	2179	39	11396	3168	21	9	42.9%	4485
OCT (80-89)	530	2186	17	13382	3402	22	9	40.9%	4951
NOV (80-89)	2103	3911	100	16180	4443	20	16	80.0%	4778
DEC (80-89)	2150	3215	300	12638	3211	17	14	82.4%	3773

FIGURE A12: Fecal coliform density in the Red River at site WQ 142 at Selkirk.

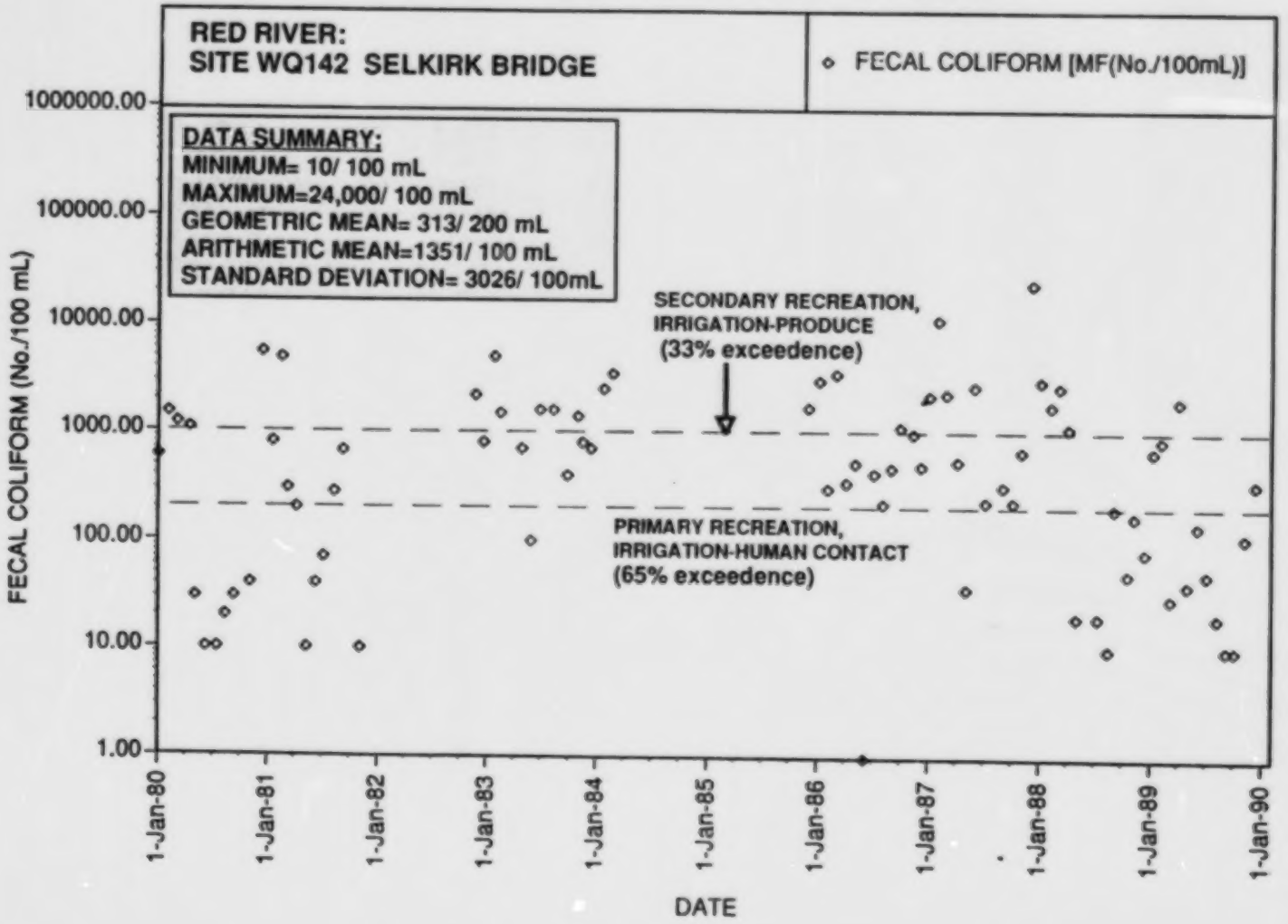


TABLE A19: Trend analysis and paired t-test results on fecal coliform data.

TREND ANALYSIS RESULTS: FECAL COLIFORM DATA. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.03	0.315	N/S	DECREASING	41
WQ451 HEADINGLEY	0.00	0.794	N/S	DECREASING	275
WQ452 WEST PERIMETER	0.00	0.626	N/S	DECREASING	281
WQ453 MAIN STREET BRIDGE	0.01	0.055	N/S	DECREASING	273
RED RIVER SITES:					
WQ367 SOUTH GATE OF FLOODWAY	0.01	0.398	N/S	DECREASING	110
WQ445 FLOODWAY CONTROL	0.00	0.840	N/S	DECREASING	293
WQ576 FORT GARY BRIDGE	0.07	0.000	**	INCREASING	189
WQ447 NORWOOD BRIDGE	0.00	0.633	N/S	INCREASING	269
WQ448 REDWOOD BRIDGE	0.01	0.216	N/S	INCREASING	278
WQ449 NORTH PERIMETER	0.01	0.061	N/S	INCREASING	286
WQ450 LOCKPORT BRIDGE	0.00	0.937	N/S	DECREASING	283
WQ142 SELKIRK	0.00	0.689	N/S	INCREASING	81

PAIRED T-TEST RESULTS: FECAL COLIFORM DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (No./100 mL)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.004	**	-4743	35
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.001	**	-5155	42
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.036	*	202	37

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)
~ indicates insufficient data to perform analysis

FIGURE A13: Turbidity levels in the Assiniboine River at site WQ018 at Headingley.

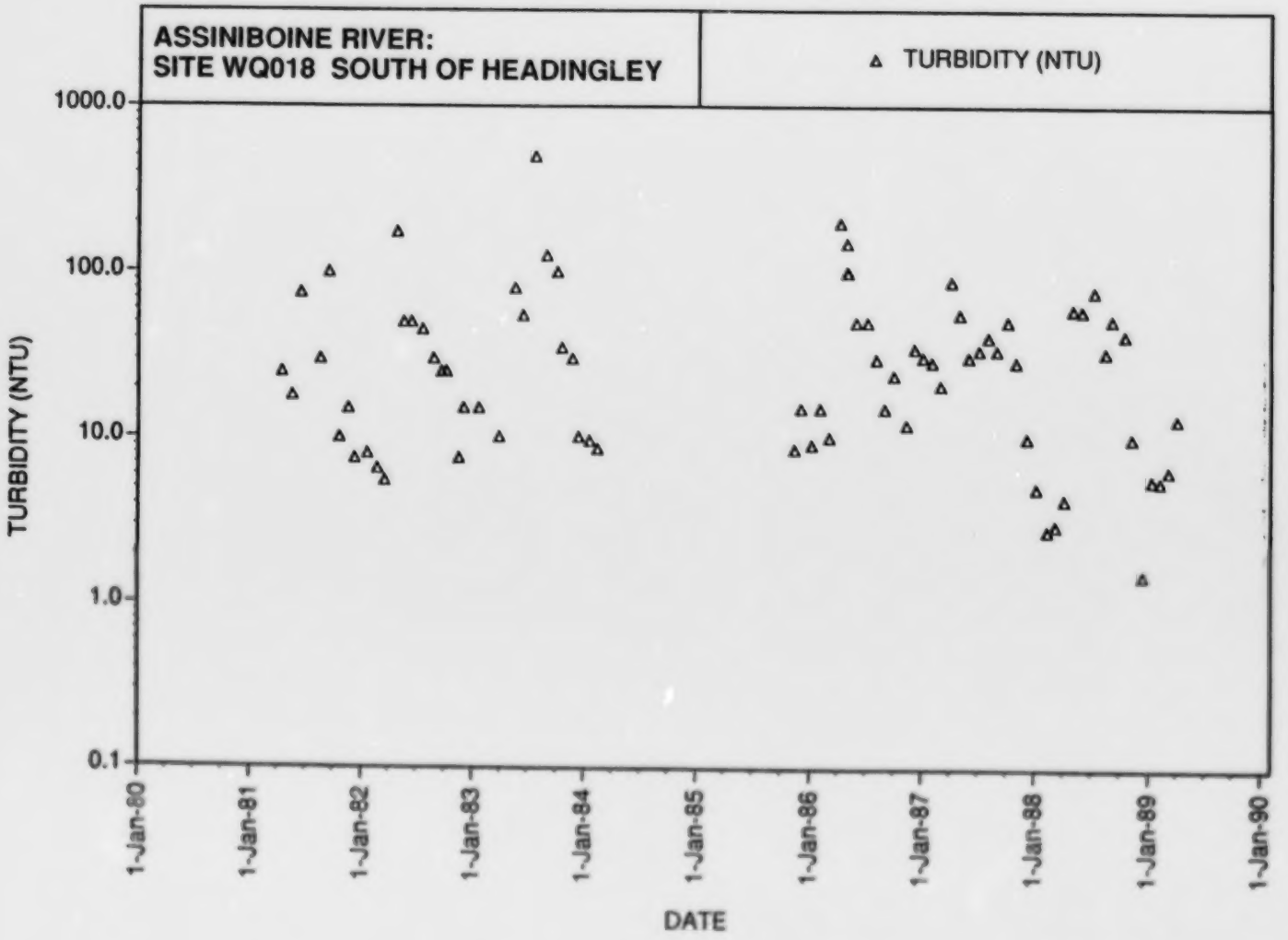


FIGURE A14: Turbidity levels in the Assiniboine River at site WQ451 at Headingley.

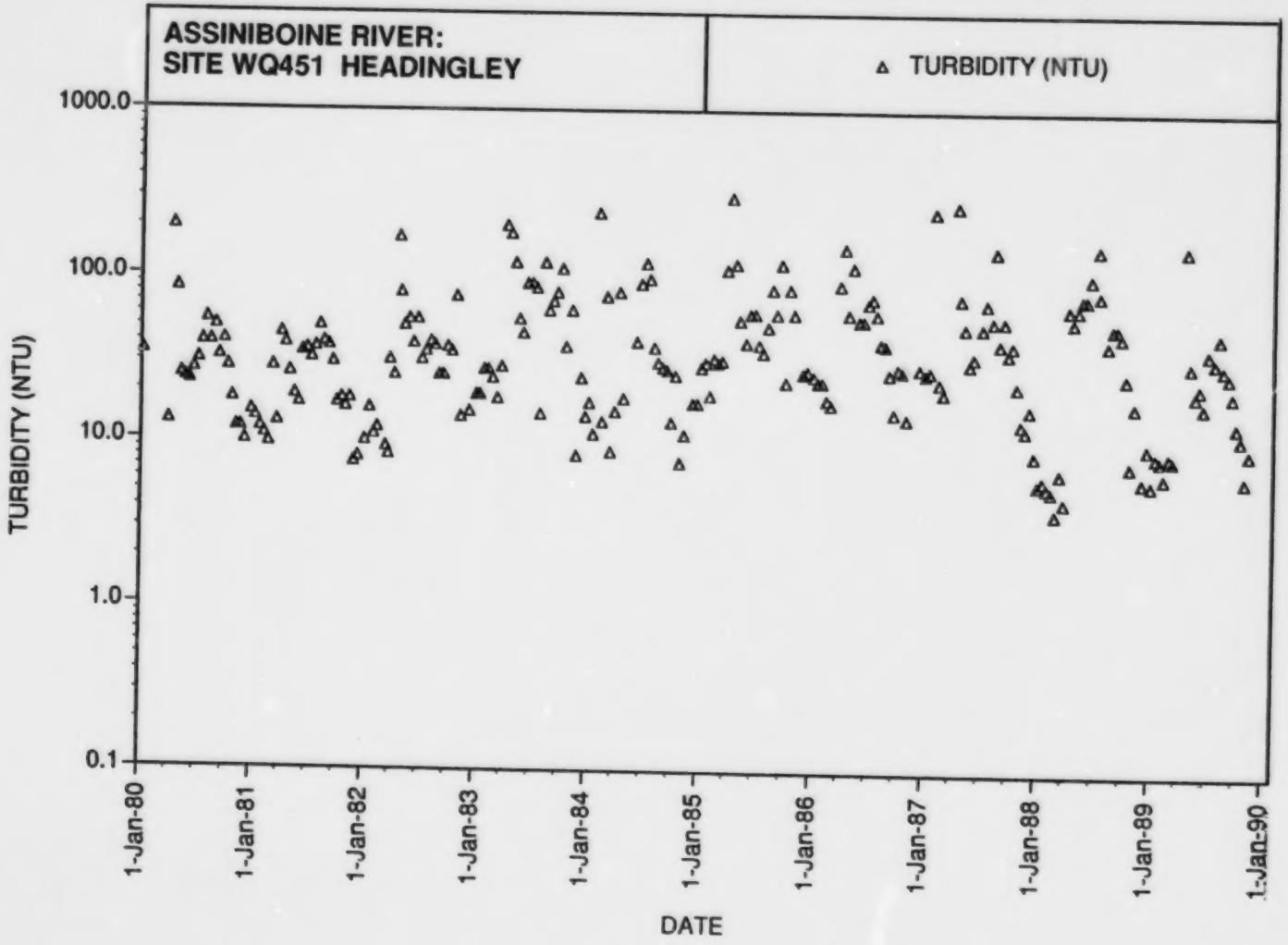


FIGURE A15: Turbidity levels in the Assiniboine River at site WQ453 at the west perimeter.

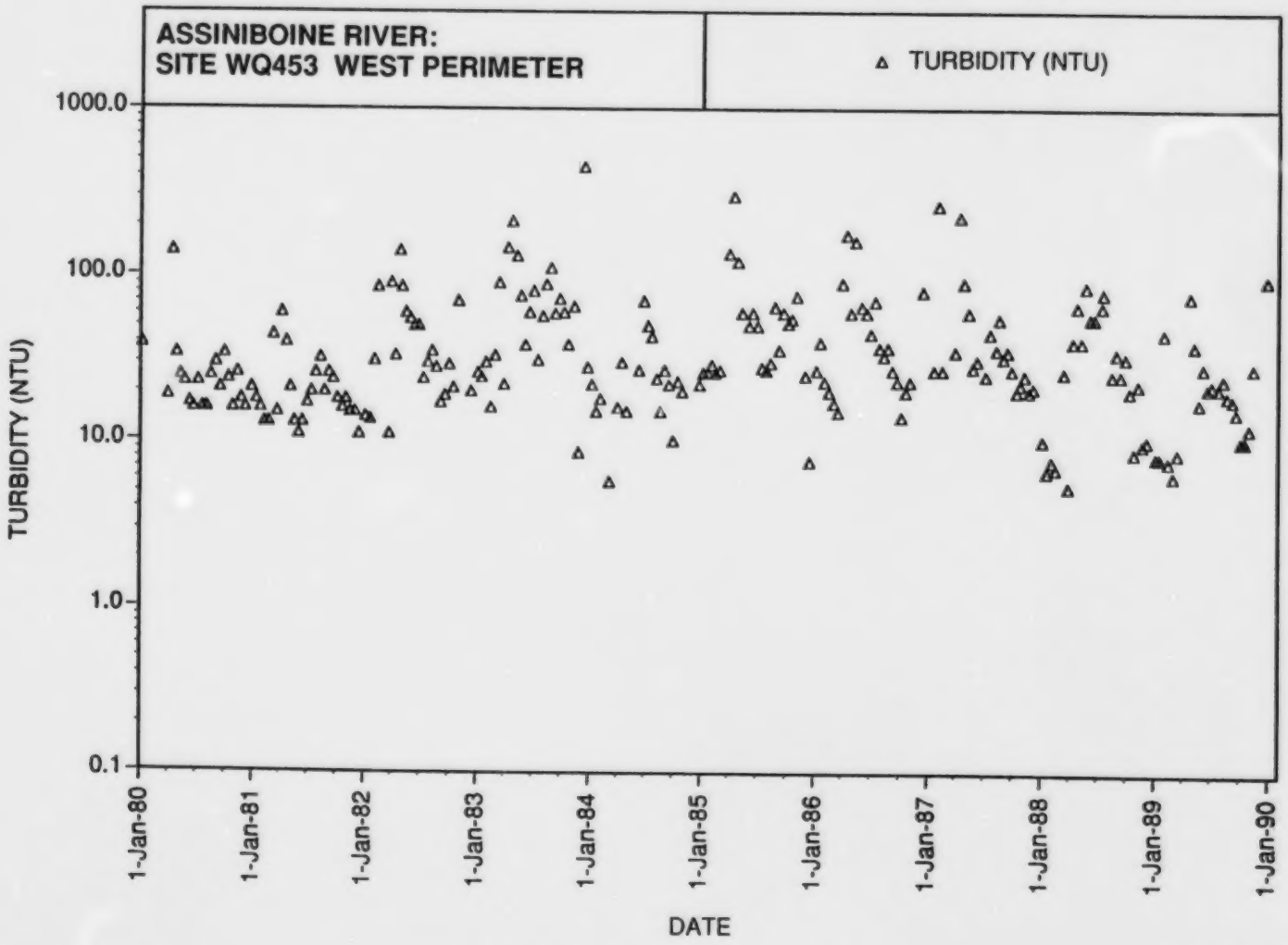


FIGURE A16: Turbidity levels in the Red River at site WQ367 at the south gate of the Floodway.

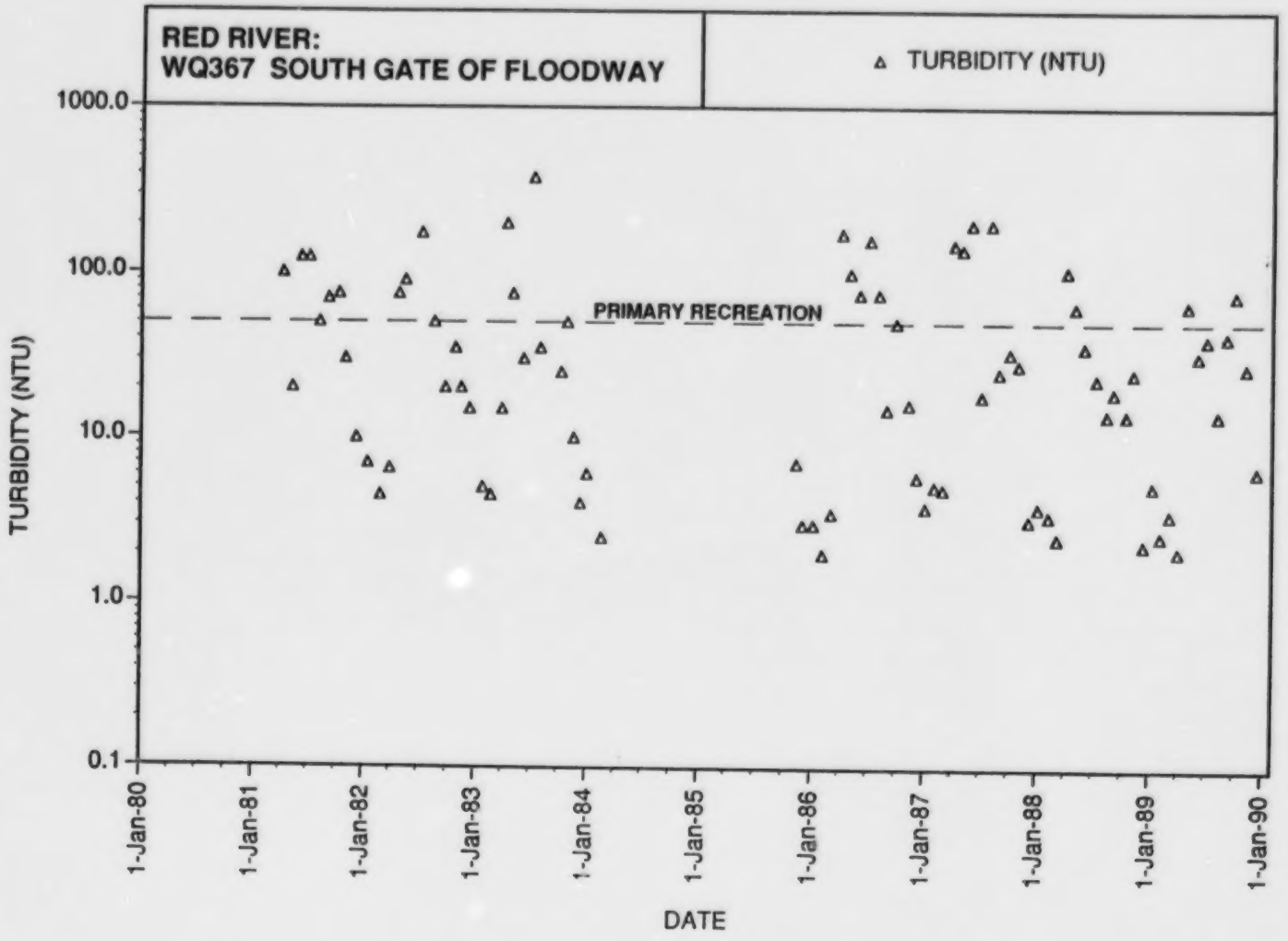


FIGURE A17: Turbidity levels in the Red River at site WQ445 at the Floodway Control.

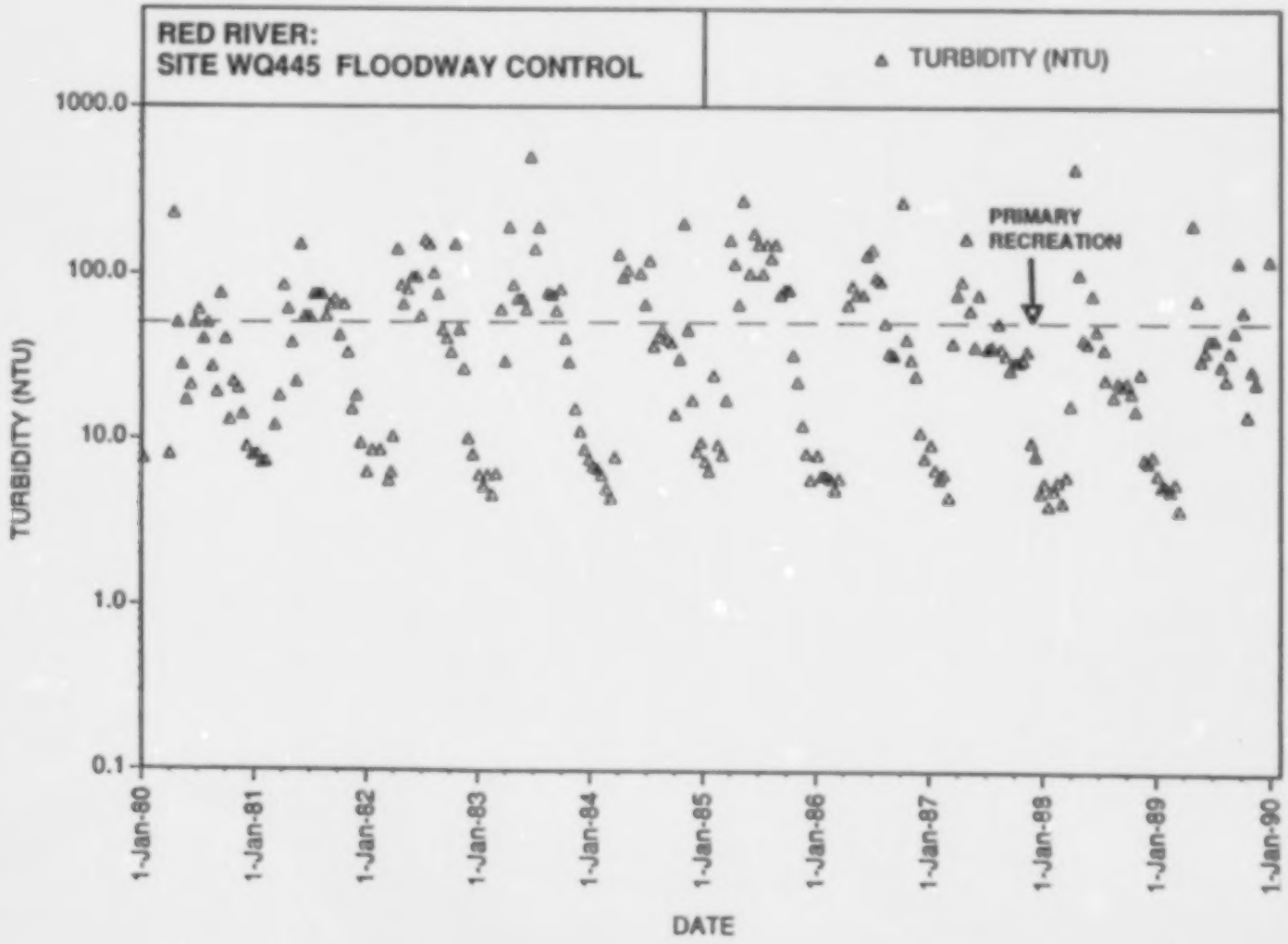


TABLE A20: Summary statistics and exceedence of the turbidity objective for primary recreation, at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: TURBIDITY (NTU)
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: 50. (NTU)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	52.4	3.8	500.0	63.4	239	83	34.73%	113.7
1980	38.6	7.6	230.0	47.9	21	3	14.29%	122.0
1981	46.5	7.2	150.0	34.2	24	12	50.00%	73.8
1982	60.1	5.6	160.0	51.0	25	12	48.00%	104.2
1983	72.9	4.6	500.0	103.7	25	13	52.00%	127.2
1984	49.0	4.4	200.0	51.0	24	7	29.17%	116.4
1985	78.1	5.7	275.0	71.1	25	14	56.00%	128.6
1986	56.1	5.0	270.0	62.2	23	9	39.13%	113.9
1987	37.2	4.5	165.0	35.6	25	5	20.00%	93.0
1988	39.9	4.0	430.0	84.4	25	3	12.00%	201.7
1989	42.7	3.8	200.0	48.3	22	5	22.73%	114.4
JAN (80-89)	6.7	5.2	9.3	1.2	19	0	0.00%	
FEB (80-89)	7.1	4.0	24.0	4.7	16	0	0.00%	
MARCH (80-89)	15.8	3.8	75.0	19.0	22	2	9.09%	67.5
APRIL (80-89)	125.4	8.1	430.0	88.5	21	19	90.48%	135.6
MAY (80-89)	65.8	17.0	275.0	59.0	17	9	52.94%	96.7
JUNE (80-89)	97.6	21.0	500.0	99.9	21	16	76.19%	116.3
JULY (80-89)	89.5	23.0	190.0	52.7	22	14	63.64%	121.1
AUG (80-89)	57.9	18.0	150.0	35.1	20	8	40.00%	91.3
SEPT (80-89)	50.7	19.0	120.0	26.5	20	8	40.00%	78.1
OCT (80-89)	57.6	13.0	270.0	65.6	22	6	27.27%	137.5
NOV (80-89)	22.1	7.7	45.0	10.8	21	0	0.00%	
DEC (80-89)	15.0	4.8	122.0	26.9	18	1	5.56%	122.0

FIGURE A18: Turbidity levels in the Red River at site WQ449 at the north perimeter.

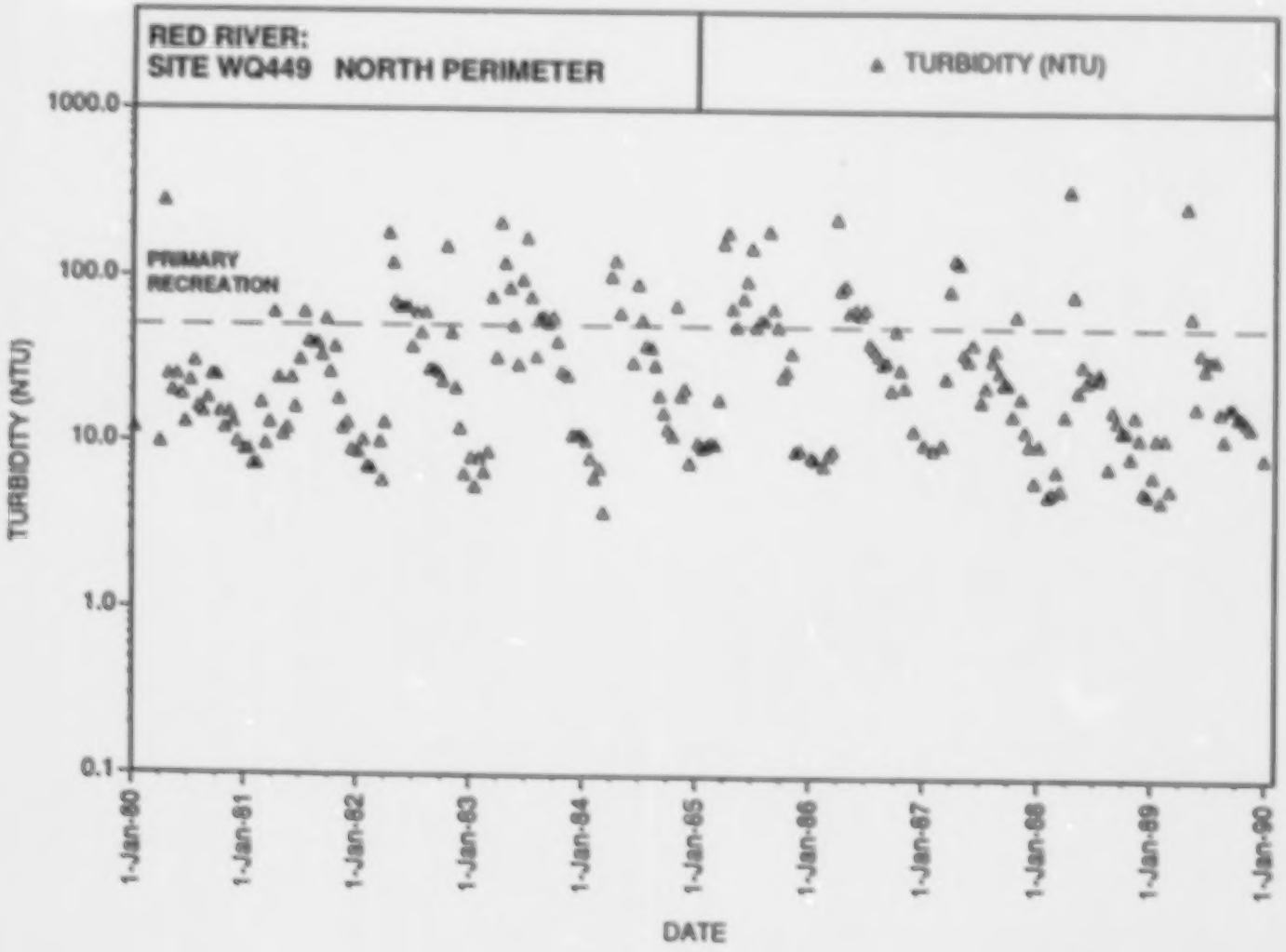


TABLE A21: Summary statistics and exceedence of the turbidity objective for primary recreation, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: TURBIDITY (NTU)
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: 50. (NTU)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	39.1	3.8	340.0	49.0	234	55	23.50%	104.4
1980	30.0	9.0	280.0	57.6	21	1	4.76%	280.0
1981	24.9	7.3	60.0	16.6	25	3	12.00%	58.3
1982	44.9	5.9	180.0	45.2	26	9	34.62%	92.8
1983	52.2	5.4	210.0	51.2	26	11	42.31%	95.6
1984	35.0	3.8	125.0	34.1	22	6	27.27%	82.8
1985	59.0	9.0	190.0	57.1	24	10	41.67%	109.5
1986	45.3	7.4	225.0	47.4	22	7	31.82%	93.1
1987	35.0	6.0	130.0	34.2	23	4	17.39%	100.0
1988	30.3	5.0	340.0	67.8	24	2	8.33%	210.0
1989	30.9	4.7	275.0	57.4	21	2	9.52%	167.5
JAN (80-89)	8.7	4.7	12.0	1.9	18	0	0.00%	
FEB (80-89)	8.2	5.0	17.0	3.0	15	0	0.00%	
MARCH (80-89)	18.5	3.8	85.0	22.2	20	2	10.00%	80.0
APRIL (80-89)	137.0	9.9	340.0	87.7	22	19	86.36%	155.5
MAY (80-89)	41.5	11.0	85.0	22.8	17	6	35.29%	67.0
JUNE (80-89)	45.9	13.0	95.0	26.7	21	8	38.10%	76.3
JULY (80-89)	52.3	18.0	170.0	38.2	22	8	36.36%	86.3
AUG (80-89)	38.8	7.4	190.0	37.7	21	5	23.81%	83.6
SEPT (80-89)	29.9	12.0	65.0	16.0	21	4	19.05%	57.3
OCT (80-89)	31.7	8.5	150.0	30.8	22	3	13.64%	92.3
NOV (80-89)	18.1	9.0	45.0	8.8	20	0	0.00%	
DEC (80-89)	8.9	5.1	13.0	2.4	15	0	0.00%	

FIGURE A19: Turbidity levels in the Red River at site WQ450 at Lockport.

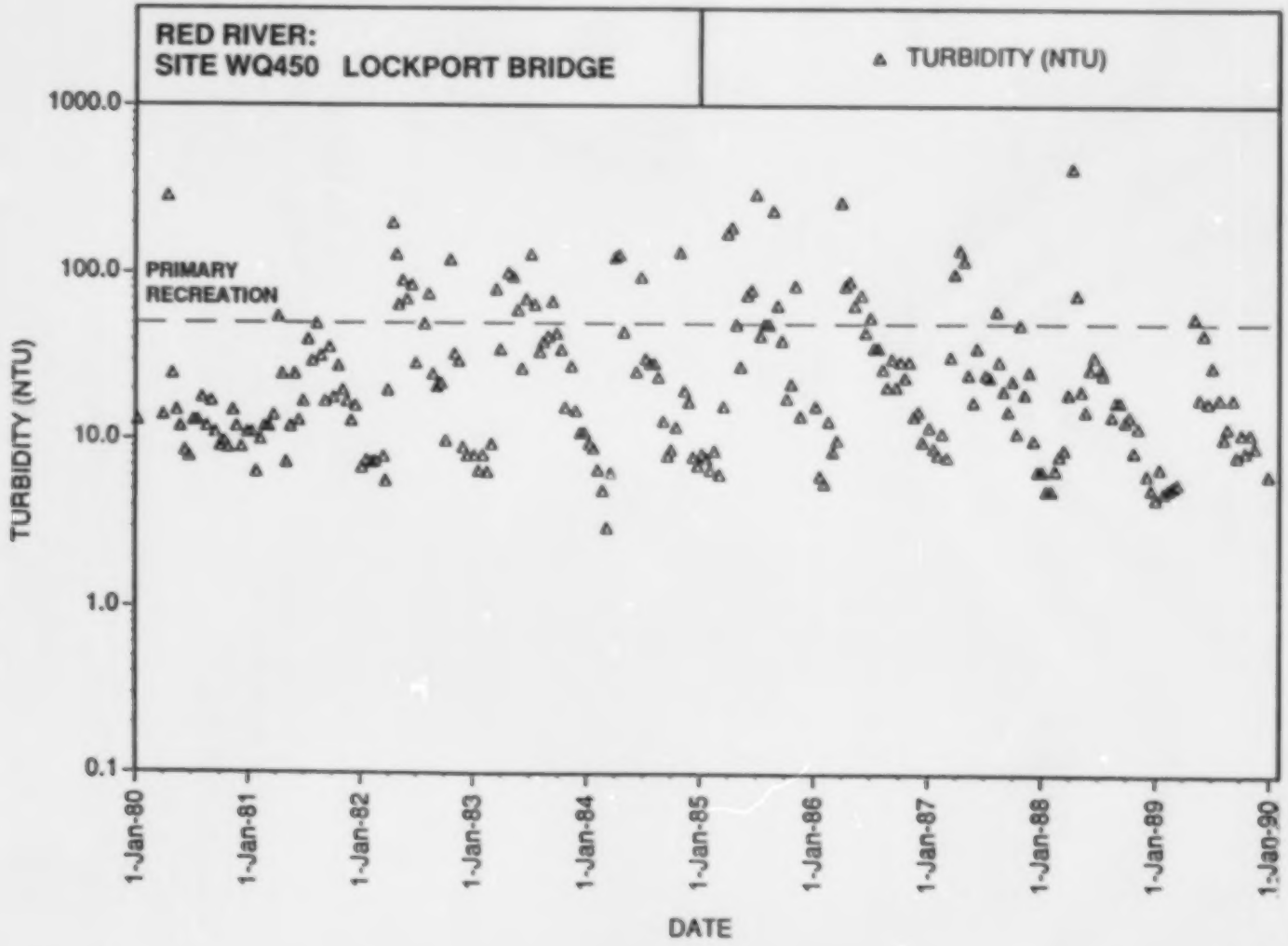


TABLE A22: Summary statistics and exceedence of the turbidity objective for primary recreation, at site WQ450 at Lockport on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: TURBIDITY (NTU)
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: 50. (NTU)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	36.3	3.0	430.0	52.9	238	43	18.07%	120.1
1980	25.9	7.9	290.0	60.6	21	1	4.76%	290.0
1981	21.5	6.4	55.0	12.9	25	1	4.00%	55.0
1982	45.4	5.7	200.0	49.0	25	8	32.00%	104.4
1983	41.7	6.4	130.0	33.9	25	8	32.00%	83.5
1984	33.4	3.0	135.0	41.9	24	4	16.67%	121.3
1985	64.0	6.1	300.0	78.8	25	8	32.00%	151.3
1986	44.2	5.5	270.0	55.0	23	6	26.09%	106.7
1987	33.5	6.5	140.0	35.5	25	4	16.00%	105.0
1988	34.0	5.0	430.0	85.6	24	2	8.33%	252.5
1989	14.6	4.5	55.0	13.2	21	1	4.76%	55.0
JAN (80-89)	8.1	4.5	13.0	2.3	17	0	0.00%	
FEB (80-89)	7.6	5.0	13.0	2.5	18	0	0.00%	
MARCH (80-89)	19.1	3.0	100.0	24.6	22	2	9.09%	90.0
APRIL (80-89)	136.0	14.0	430.0	102.7	20	16	80.00%	162.8
MAY (80-89)	37.9	7.3	95.0	28.5	17	6	35.29%	71.7
JUNE (80-89)	43.1	7.9	95.0	27.9	21	7	33.33%	78.6
JULY (80-89)	50.9	13.0	300.0	62.3	21	4	19.05%	137.5
AUG (80-89)	41.0	10.4	240.0	48.6	21	3	14.29%	125.0
SEPT (80-89)	25.1	8.0	68.0	16.8	21	2	9.52%	66.5
OCT (80-89)	27.6	8.5	135.0	34.1	22	2	9.09%	127.5
NOV (80-89)	21.8	9.0	85.0	16.6	20	1	5.00%	85.0
DEC (80-89)	9.7	5.1	16.0	3.5	18	0	0.00%	

FIGURE A20: Turbidity levels in the Red River at site WQ018 at Selkirk.

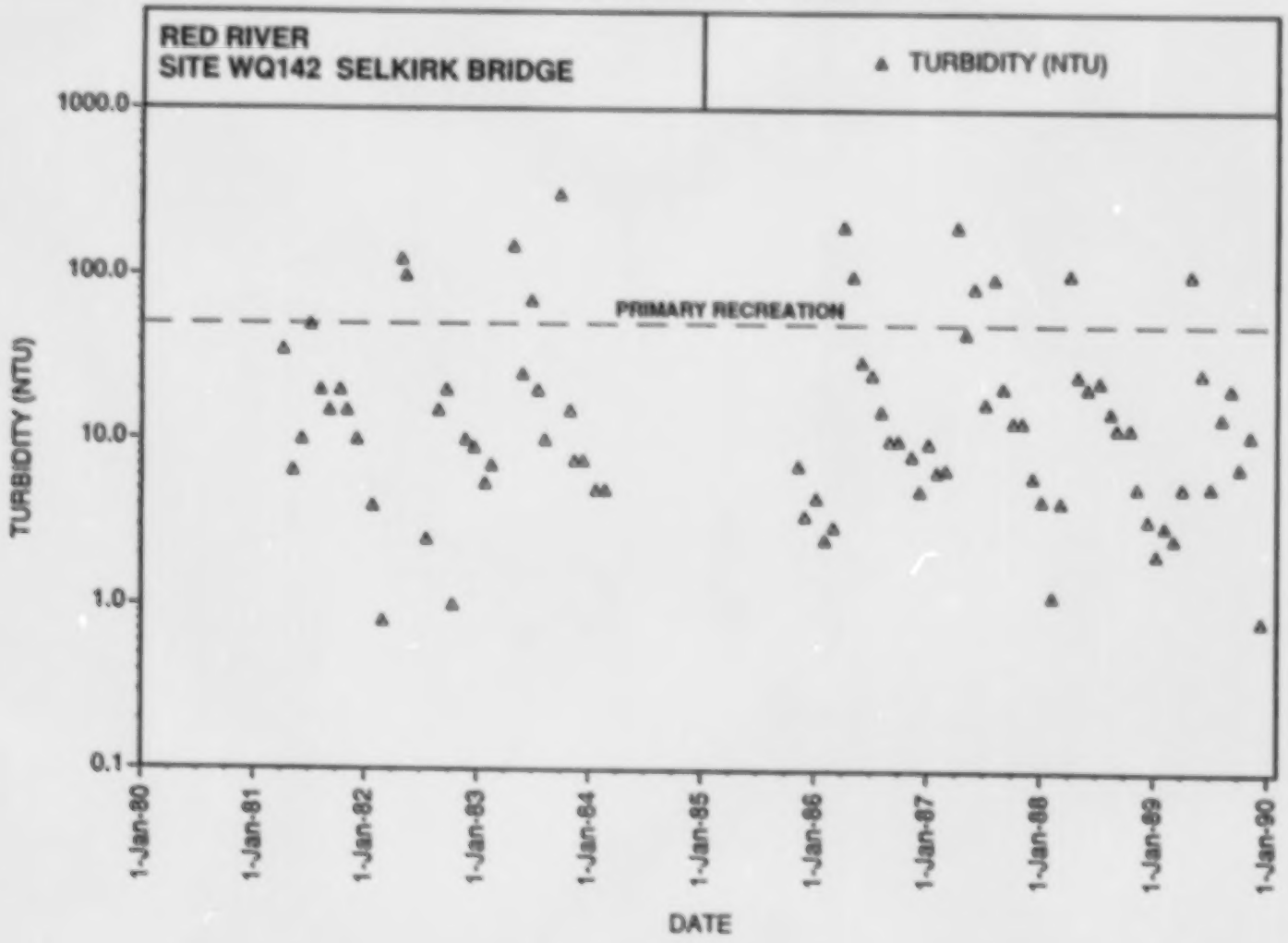


TABLE A23: Trend analysis and paired t-test results on turbidity data.

TREND ANALYSIS RESULTS: TURBIDITY DATA. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.01	0.309 N/S	DECREASING	97
WQ451 HEADINGLEY	0.00	0.830 N/S	INCREASING	235
WQ452 WEST PERIMETER	~	~ ~	~	~
WQ453 MAIN STREET BRIDGE	0.00	0.956 N/S	INCREASING	226
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.02	0.175 N/S	DECREASING	83
WQ445 FLOODWAY CONTROL	0.00	0.490 N/S	DECREASING	305
WQ576 FORT GARY BRIDGE	~	~ ~	~	~
WQ447 NORWOOD BRIDGE	~	~ ~	~	~
WQ448 REDWOOD BRIDGE	~	~ ~	~	~
WQ449 NORTH PERIMETER	0.00	0.852 N/S	DECREASING	234
WQ450 LOCKPORT BRIDGE	0.00	0.803 N/S	DECREASING	238
WQ142 SELKIRK	0.01	0.387 N/S	DECREASING	131

PAIRED T-TEST RESULTS: TURBIDITY DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (NTU)	DEGREES OF FREEDOM
SOUTH OF HEADINGLEY vs SELKIRK	HEADINGLEY	0.186 N/S	12	63
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.008 **	22.5	75
SOUTH OF HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.188 N/S	-8.2	65

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

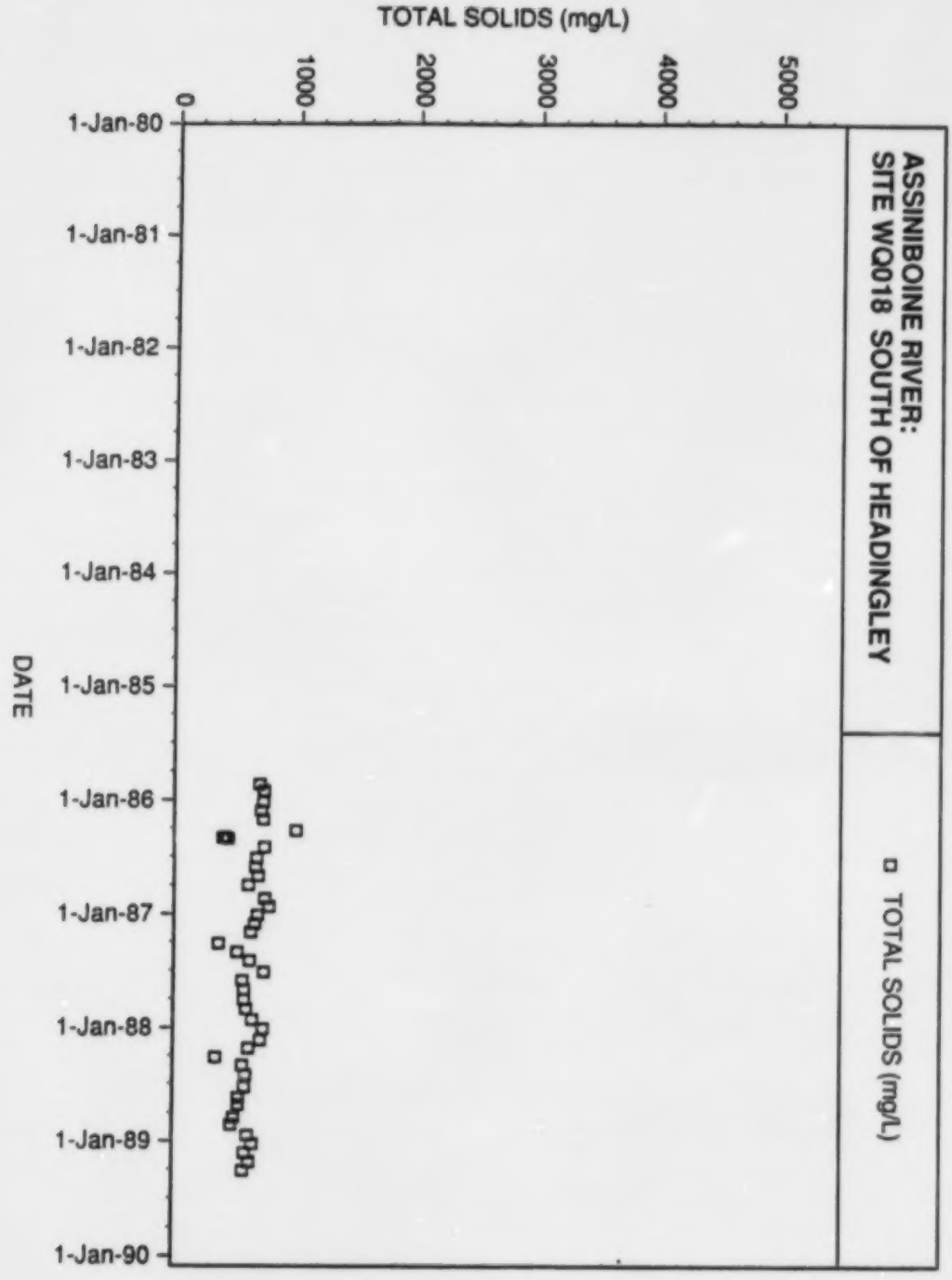


FIGURE A21: Total solids in the Assiniboine River at site WQ018 at Headingley.

FIGURE A22: Total solids in the Assiniboine River at site WQ451 at Headingley.

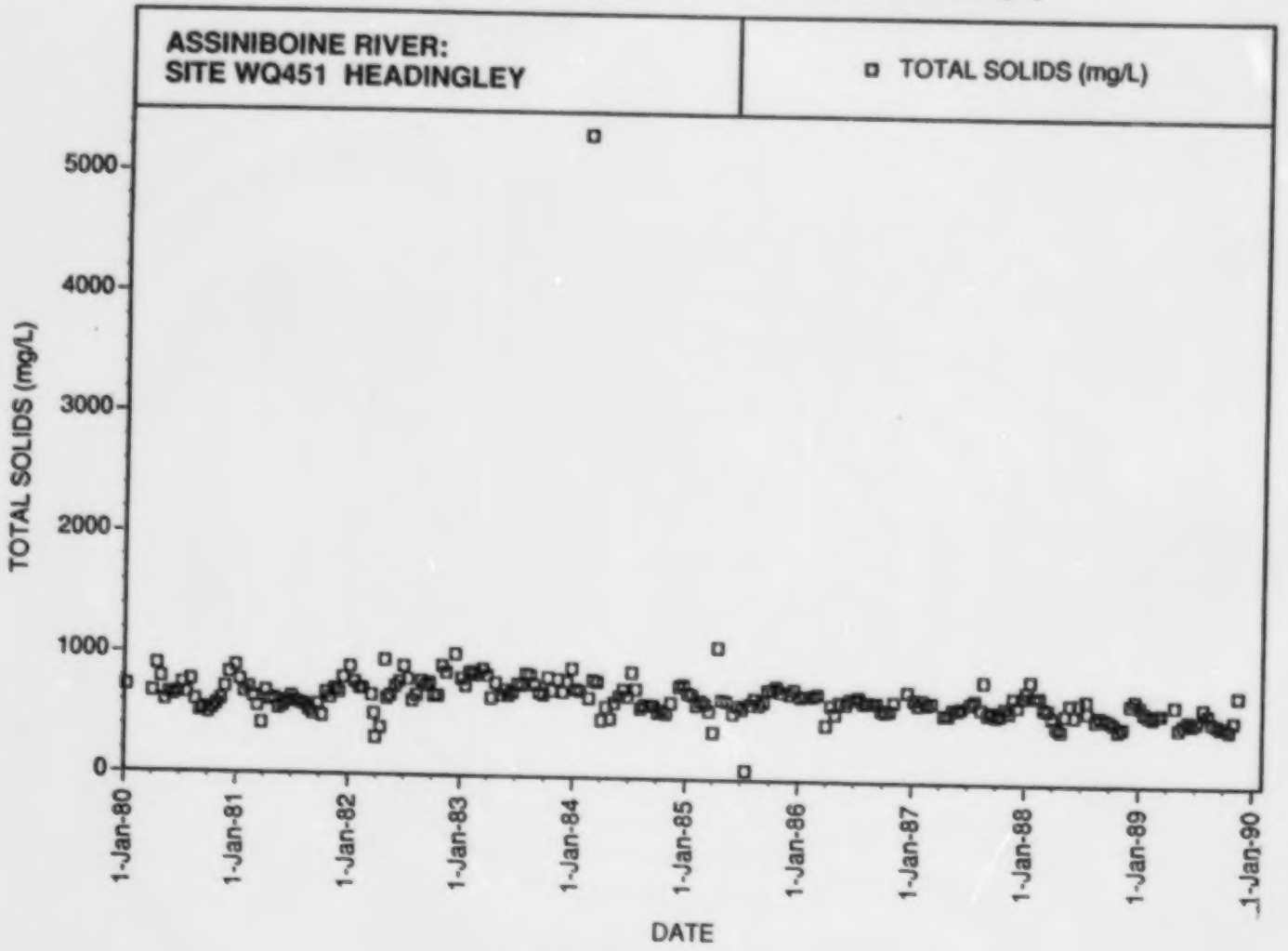
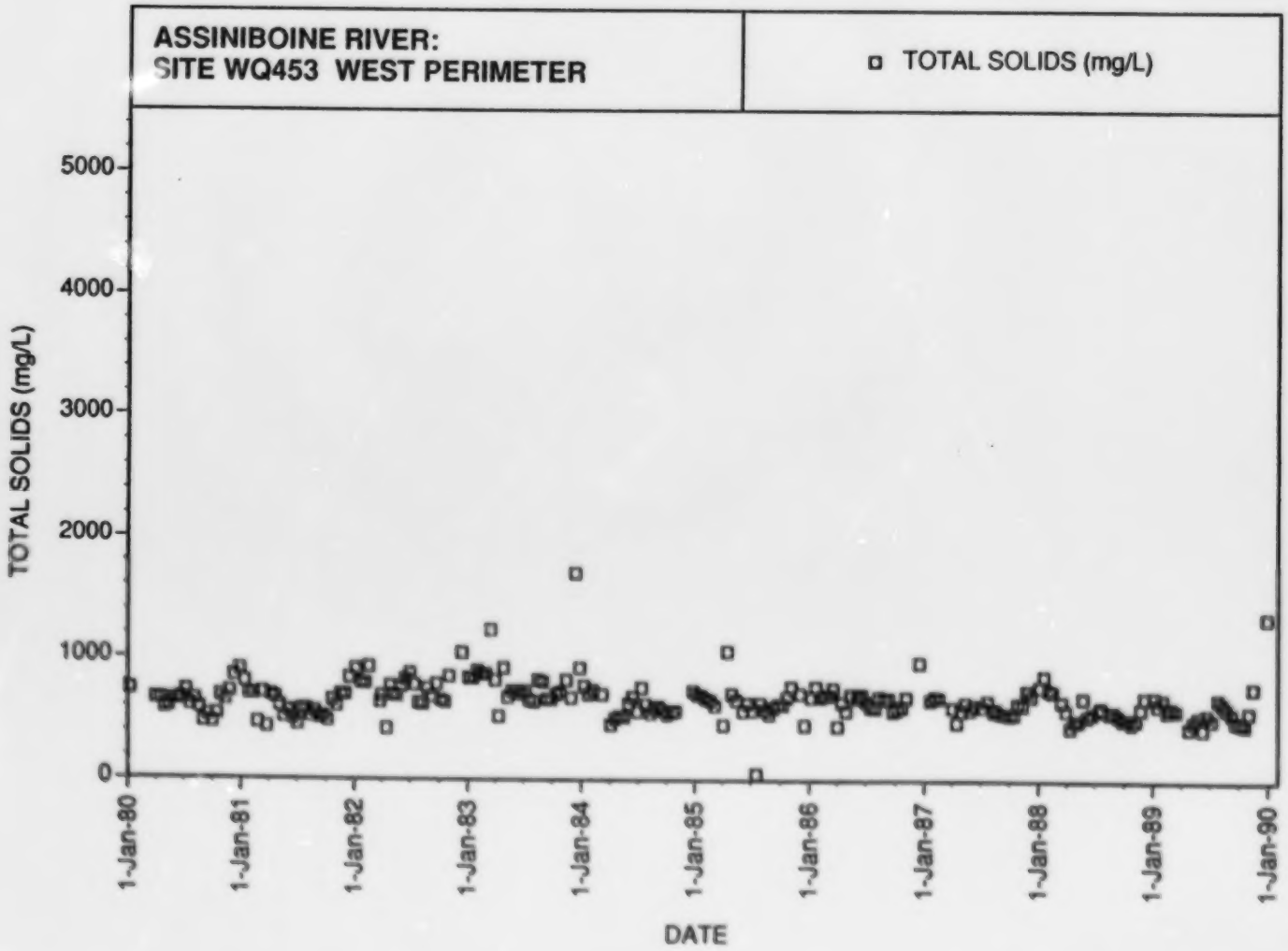


FIGURE A23: Total solids in the Assiniboine River at site WQ453 at the west perimeter.



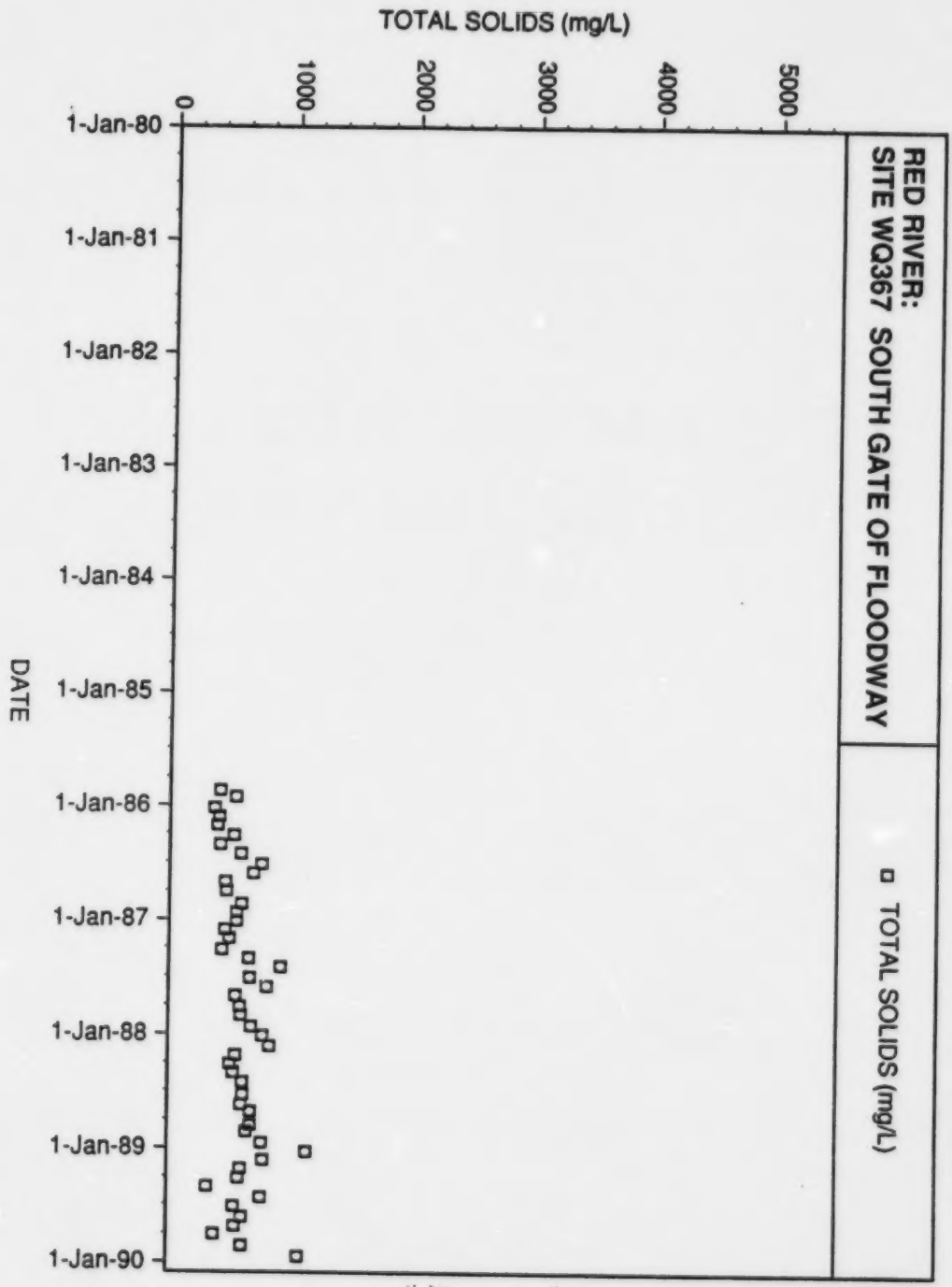


FIGURE A24: Total solids in the Red River at site WQ367 at the south gate of the Floodway.

FIGURE A25: Total solids in the Red River at site WQ445 at the Floodway control.

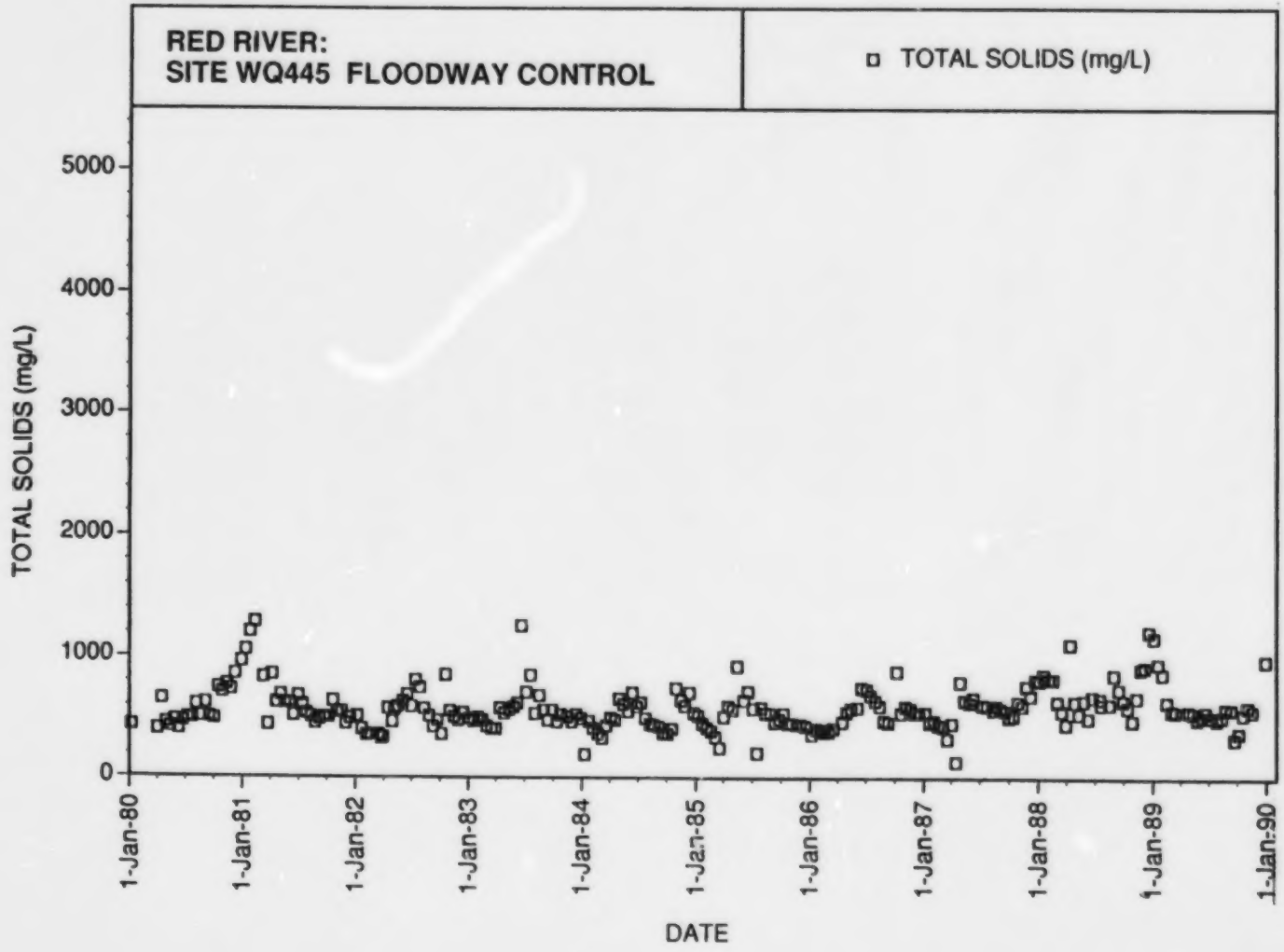


FIGURE A26: Total solids in the Red River at site WQ449 at the north perimeter.

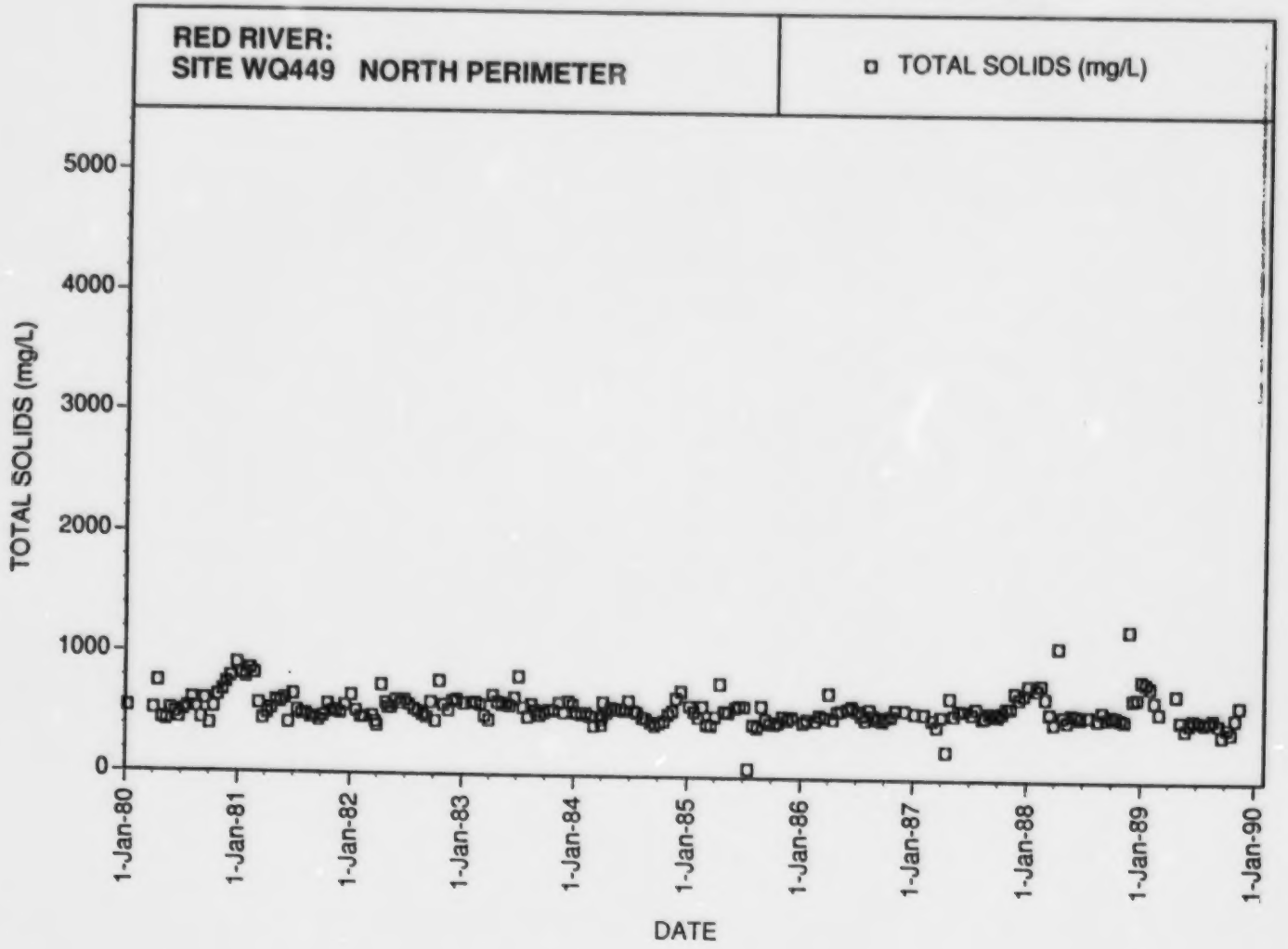
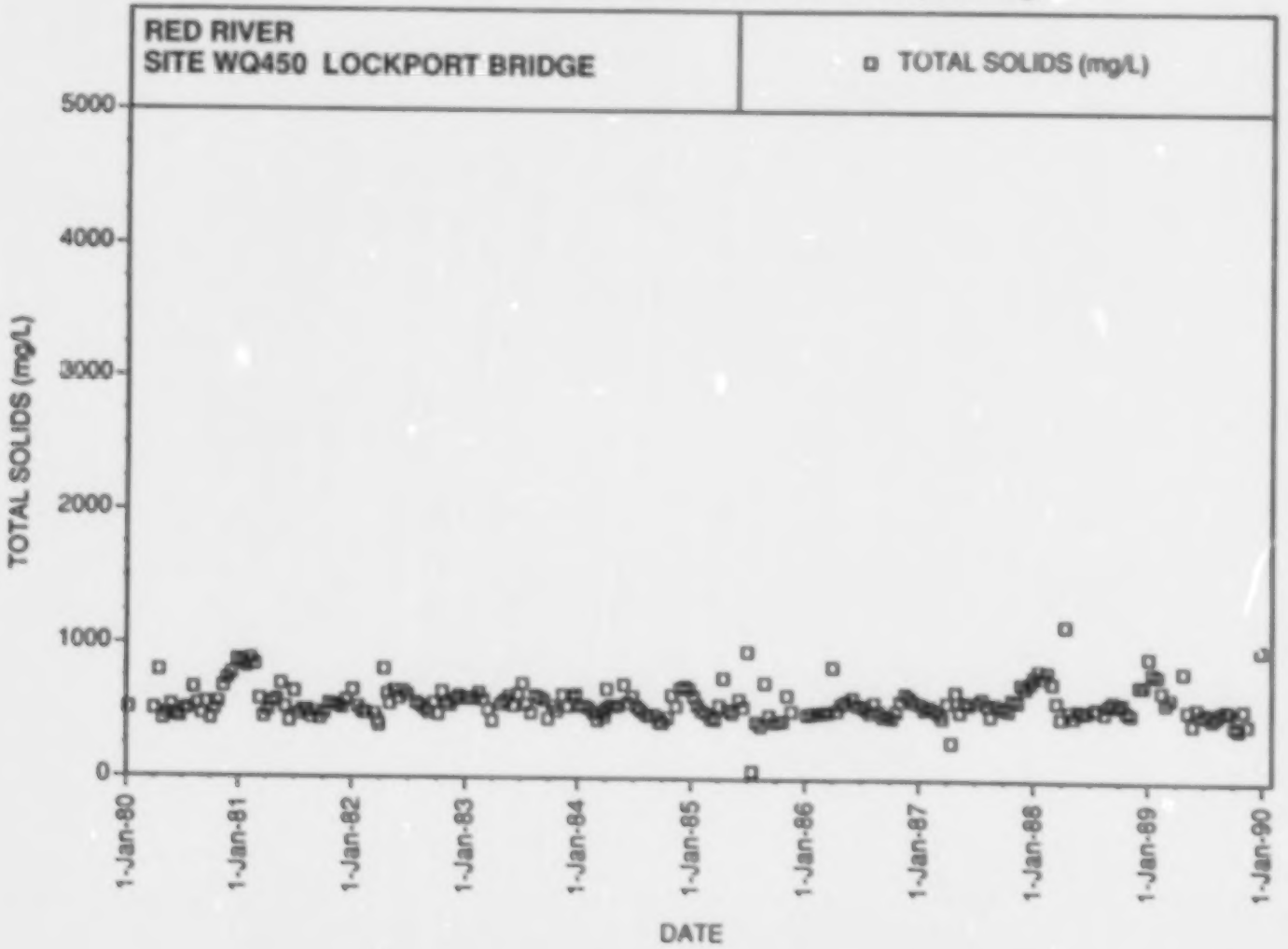


FIGURE A27: Total solids in the Red River at site WQ450 at the Lockport Bridge.



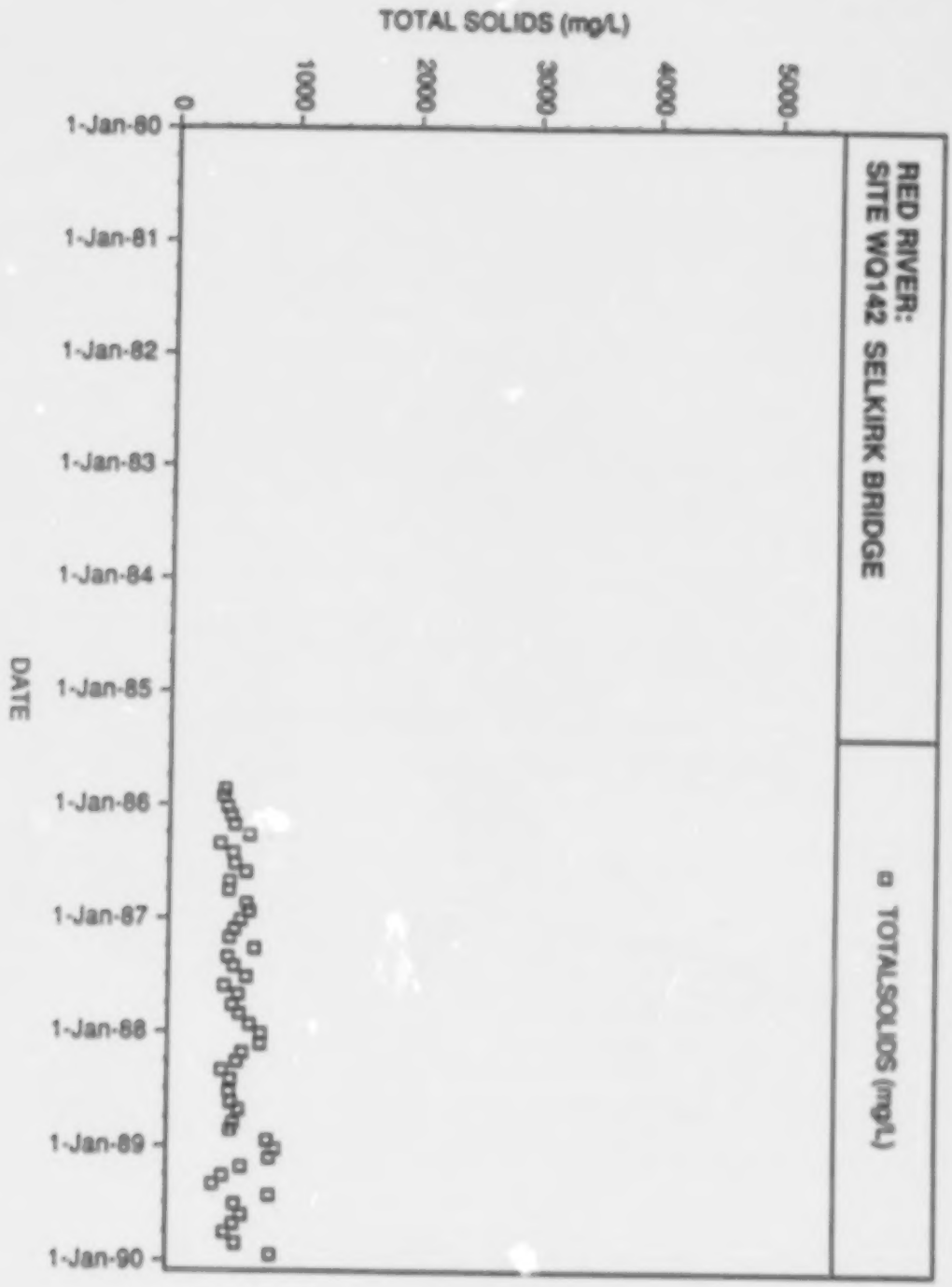


FIGURE A28: Total Solids in the Red River at site WQ142 at the Selkirk Bridge.

TABLE A24: Trend analysis and paired t-test results on total solids data.

TREND ANALYSIS RESULTS: TOTAL SOLIDS. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.22	0.000 **	DECREASING	130
WQ451 HEADINGLEY	0.01	0.070 N/S	DECREASING	236
WQ452 WEST PERIMETER	-	- -	-	-
WQ453 MAIN STREET BRIDGE	0.04	0.002 **	DECREASING	228
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.10	0.027 *	INCREASING	49
WQ445 FLOODWAY CONTROL	-	- -	-	-
WQ576 FORT GARY BRIDGE	-	- -	-	-
WQ447 NORWOOD BRIDGE	-	- -	-	-
WQ448 REDWOOD BRIDGE	-	- -	-	-
WQ449 NORTH PERIMETER	0.00	0.695 N/S	INCREASING	237
WQ450 LOCKPORT BRIDGE	0.00	0.333 N/S	INCREASING	244
WQ142 SELKIRK	0.00	0.534 N/S	DECREASING	134

PAIRED T-TEST RESULTS: TOTAL SOLIDS UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1986-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.031 *	51.1	41
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.209 N/S	21.9	48
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.471 N/S	21.6	41

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

\- indicates insufficient data to perform analysis

FIGURE A29: Total suspended solids in the Assiniboine River, at site WQ108 at Headingley.

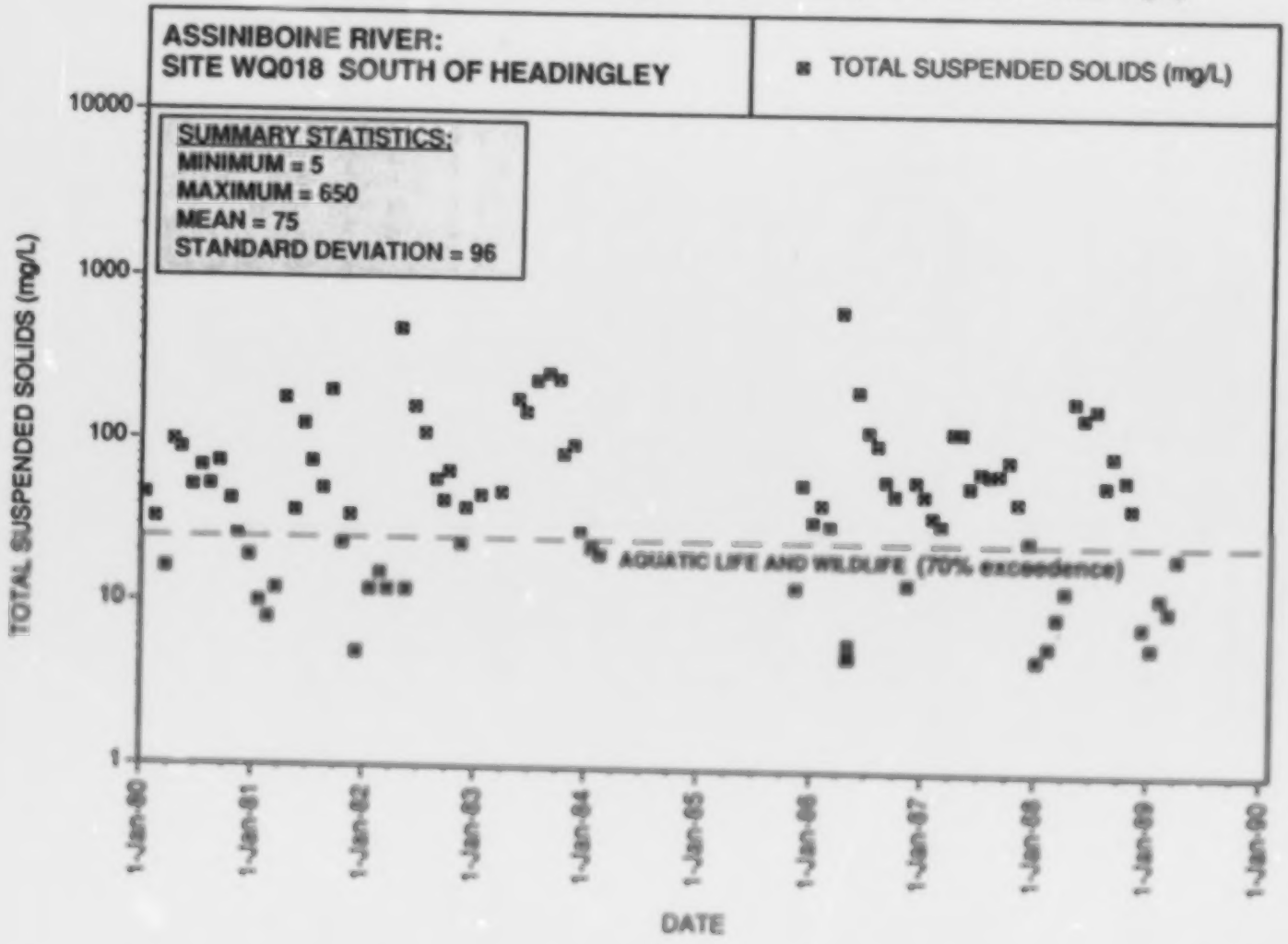


FIGURE A30: Total suspended solids in the Assiniboine River, at site WQ018 at Headingley.

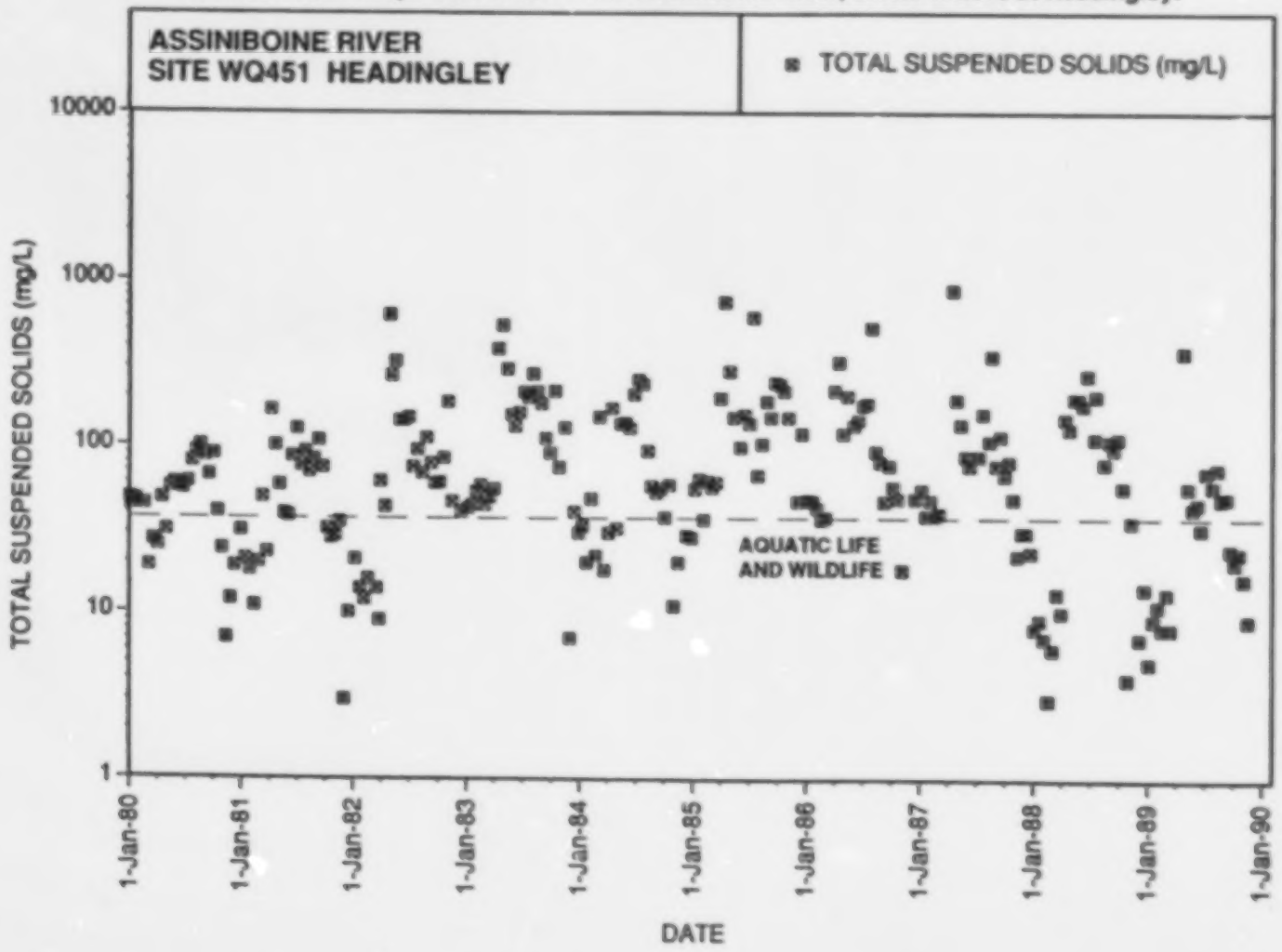


TABLE A25: Summary statistics and exceedence of the total suspended solids objective for aquatic life and wildlife at site WQ451 at Headingley on the Assiniboine River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: TOTAL SUSPENDED SOLIDS
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 25. (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	98.5	3.0	866.0	116.5	241	192	79.7%	120.1
1980	48.7	7.0	100.0	25.8	26	20	76.9%	58.0
1981	55.7	3.0	164.0	41.0	25	18	72.0%	71.5
1982	109.0	9.0	614.0	131.4	25	19	76.0%	138.8
1983	144.5	7.0	530.0	123.0	26	25	96.2%	150.0
1984	82.0	11.0	250.0	72.6	25	20	80.0%	97.9
1985	173.9	36.0	732.0	166.9	24	24	100.0%	173.9
1986	121.3	18.0	514.0	116.2	22	21	95.5%	126.2
1987	119.7	22.0	866.0	177.9	23	21	91.3%	129.0
1988	82.2	3.0	268.0	80.1	24	14	58.3%	135.1
1989	46.8	5.0	366.0	76.3	21	10	47.6%	83.7
JAN (80-89)	31.7	5.0	63.0	18.3	22	12	54.5%	46.8
FEB (80-89)	31.2	3.0	61.0	19.0	18	10	55.6%	46.3
MARCH (80-89)	36.1	6.0	149.0	32.1	21	11	52.4%	56.9
APRIL (80-89)	258.8	25.0	866.0	236.8	22	21	95.5%	270.0
MAY (80-89)	136.8	32.0	324.0	89.2	19	19	100.0%	136.8
JUNE (80-89)	120.8	32.0	268.0	58.8	21	21	100.0%	120.8
JULY (80-89)	168.6	57.0	594.0	139.4	22	22	100.0%	168.6
AUG (80-89)	121.8	48.0	348.0	76.2	21	21	100.0%	121.8
SEPT (80-89)	86.9	24.0	242.0	45.6	21	20	95.2%	90.1
OCT (80-89)	69.7	4.0	234.0	65.6	22	17	77.3%	85.4
NOV (80-89)	46.6	7.0	184.0	55.0	16	8	50.0%	79.4
DEC (80-89)	32.3	3.0	118.0	26.5	16	10	62.5%	44.0

FIGURE A31: Total suspended solids in the Assiniboine River at site WQ453, at the MainStreet Bridge.

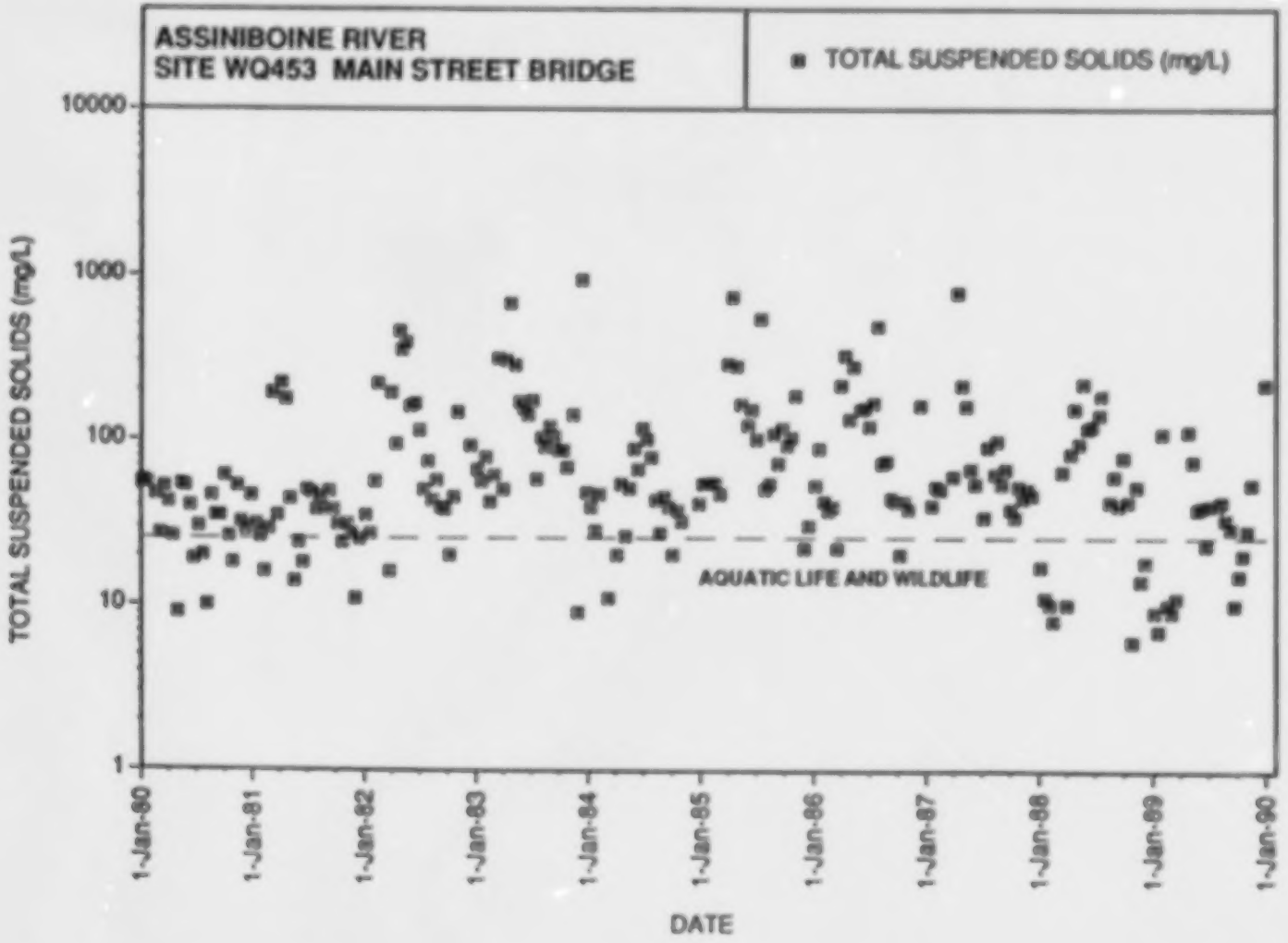


TABLE A26: Summary statistics and exceedence of the total suspended solids objective for aquatic life and wildlife at site WQ453 at the Main Street Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: TOTAL SUSPENDED SOLIDS
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 25. (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	92.0	6.0	936.0	123.9	233	195	83.7%	107.0
1980	37.6	9.0	61.0	15.4	26	21	80.8%	42.9
1981	51.0	11.0	218.0	55.4	25	18	72.0%	63.5
1982	124.5	16.0	452.0	122.5	23	21	91.3%	134.7
1983	168.8	9.0	936.0	205.9	26	25	96.2%	175.2
1984	48.0	11.0	116.0	27.5	21	18	85.7%	53.2
1985	150.5	22.0	736.0	171.3	23	22	95.7%	156.4
1986	120.9	20.0	484.0	113.6	23	21	91.3%	130.4
1987	101.8	34.0	780.0	161.1	21	21	100.0%	101.8
1988	68.4	6.0	216.0	60.7	23	15	65.2%	98.7
1989	43.9	7.0	214.0	48.1	22	13	59.1%	65.5
JAN (80-89)	43.7	7.0	109.0	25.5	21	17	81.0%	51.4
FEB (80-89)	50.0	8.0	217.0	47.2	17	13	76.5%	62.0
MARCH (80-89)	66.9	9.0	308.0	80.7	18	12	66.7%	93.8
APRIL (80-89)	243.4	9.0	780.0	228.1	22	20	90.9%	266.3
MAY (80-89)	136.6	14.0	388.0	114.4	19	18	94.7%	143.4
JUNE (80-89)	94.7	18.0	164.0	54.2	21	17	81.0%	112.1
JULY (80-89)	120.5	20.0	540.0	135.8	22	21	95.5%	125.2
AUG (80-89)	60.3	10.0	120.0	29.0	21	20	95.2%	62.8
SEPT (80-89)	52.2	10.0	116.0	25.9	21	20	95.2%	54.4
OCT (80-89)	40.6	6.0	102.0	26.3	22	14	63.6%	53.6
NOV (80-89)	60.0	9.0	182.0	52.2	15	13	86.7%	67.5
DEC (80-89)	122.7	11.0	936.0	241.3	14	10	71.4%	164.2

FIGURE A32: Total suspended solids in the Red River, at site WQ367 at the south gate of the Floodway.

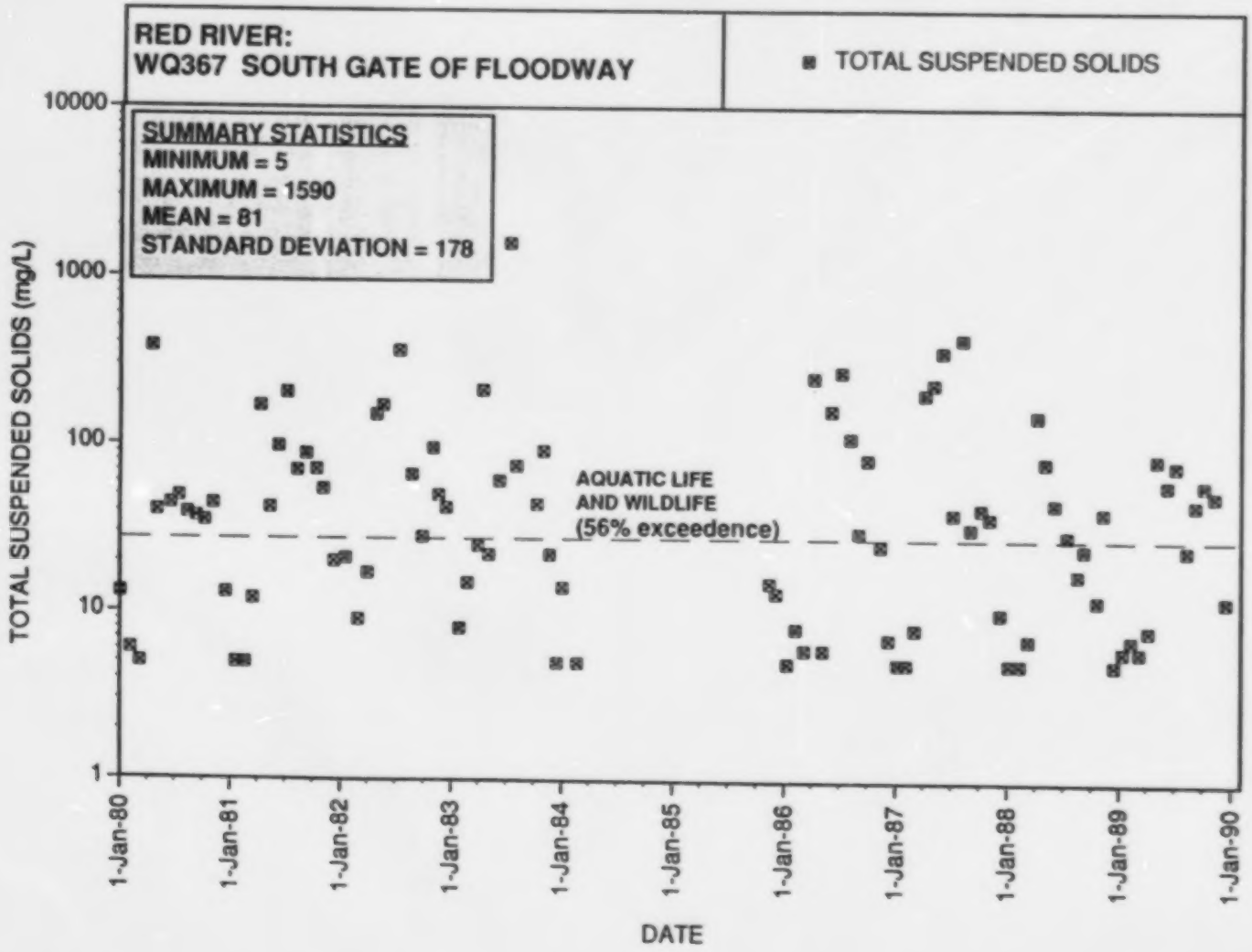


FIGURE A33: Total suspended solids in the Red River, at site WQ445 at the south Floodway Control.

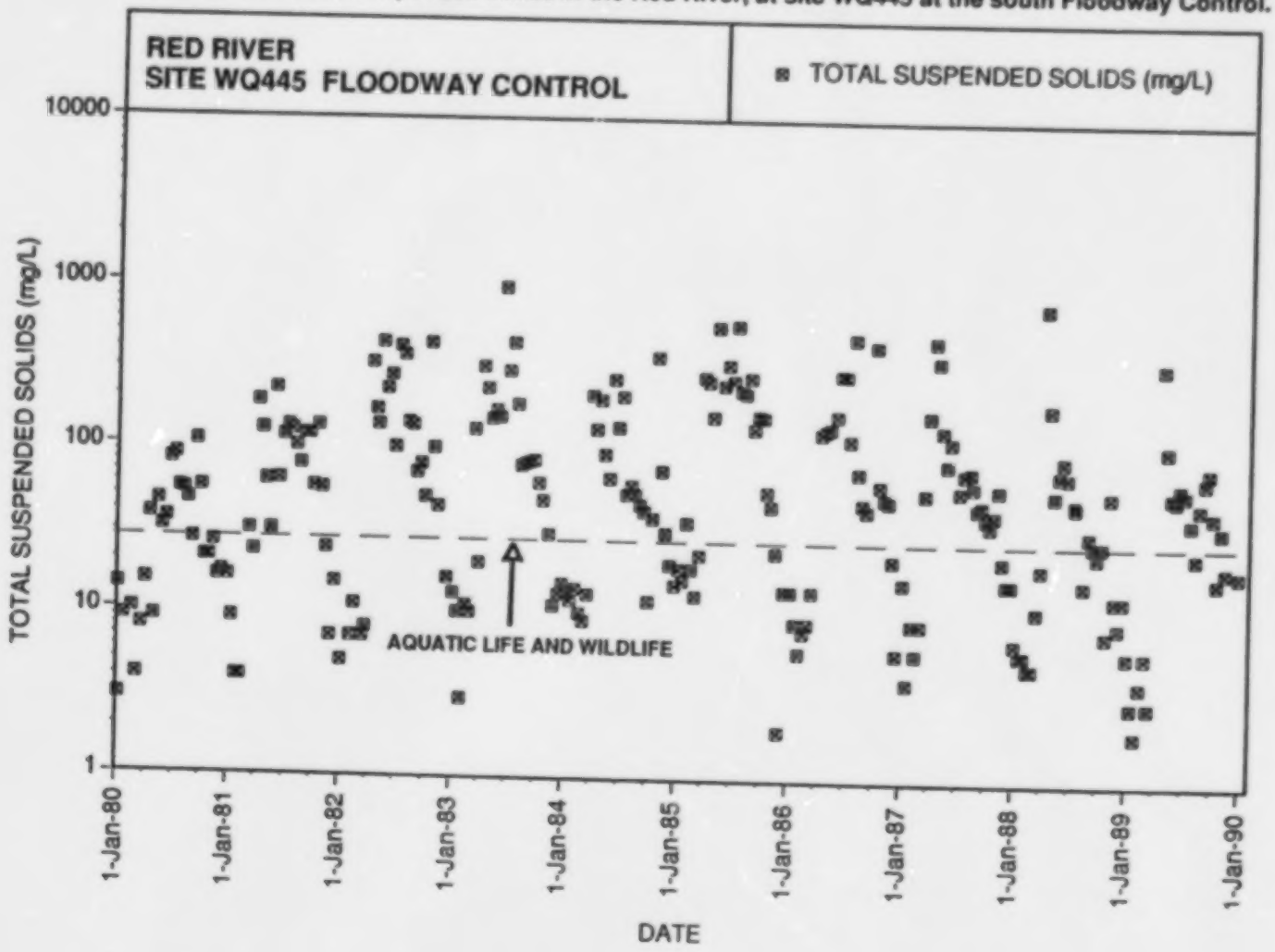


TABLE A27: Summary statistics and exceedence of the total suspended solids objective for aquatic life and wildlife at site WQ445 at the south Floodway Control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: TOTAL SUSPENDED SOLIDS
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 25. (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	95.5	2.0	945.0	131.3	245	154	62.86%	144.9
1980	32.9	3.0	106.0	27.2	26	13	50.00%	53.3
1981	76.6	4.0	222.0	60.6	24	17	70.83%	103.1
1982	153.8	5.0	436.0	148.4	23	17	73.91%	204.9
1983	136.8	3.0	945.0	198.7	26	17	65.38%	203.0
1984	83.6	9.0	364.0	92.6	26	17	65.38%	120.9
1985	164.2	2.0	576.0	161.8	25	17	68.00%	233.8
1986	112.8	6.0	488.0	137.5	23	15	65.22%	167.1
1987	80.7	4.0	472.0	109.1	25	17	68.00%	112.9
1988	65.1	5.0	766.0	151.3	25	12	48.00%	123.7
1989	49.6	2.0	338.0	70.5	22	12	54.55%	82.3
JAN (80-89)	9.4	2.0	19.0	5.1	20	0	0.00%	
FEB (80-89)	9.7	3.0	36.0	7.7	18	1	5.56%	36.0
MARCH (80-89)	25.8	3.0	164.0	40.0	23	4	17.39%	94.8
APRIL (80-89)	228.8	9.0	766.0	169.9	21	19	90.48%	251.6
MAY (80-89)	137.8	31.0	560.0	136.8	19	19	100.00%	137.8
JUNE (80-89)	191.8	36.0	945.0	193.9	21	21	100.00%	191.8
JULY (80-89)	202.2	39.0	576.0	165.2	22	22	100.00%	202.2
AUG (80-89)	89.6	16.0	274.0	66.2	21	19	90.48%	96.9
SEPT (80-89)	72.2	24.0	160.0	38.5	20	19	95.00%	74.7
OCT (80-89)	99.0	8.0	438.0	132.3	22	17	77.27%	123.5
NOV (80-89)	39.4	11.0	98.0	22.4	20	13	65.00%	50.6
DEC (80-89)	13.9	2.0	22.0	5.1	18	0	0.00%	

FIGURE A34: Total suspended solids in the Red River, at site WQ449 at the north perimeter.

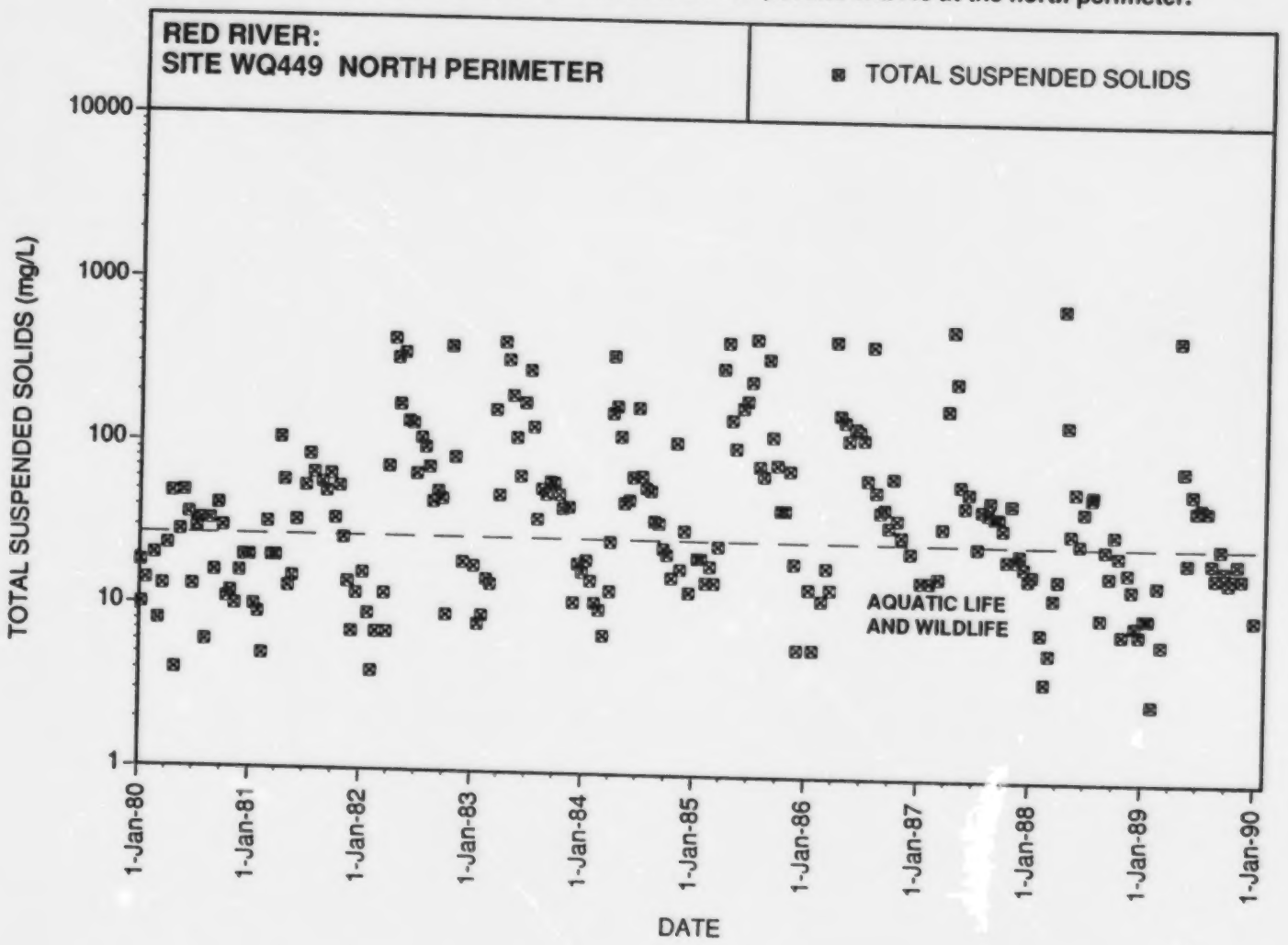


TABLE A28: Summary statistics and exceedence of the total suspended solids objective for aquatic life and wildlife at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: TOTAL SUSPENDED SOLIDS
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 25. (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	73.0	3.0	756.0	110.2	240	136	56.67%	117.8
1980	21.6	4.0	49.0	12.6	26	9	34.62%	36.4
1981	36.6	5.0	106.0	27.4	23	13	56.52%	55.2
1982	111.2	4.0	432.0	131.0	24	16	66.67%	161.6
1983	93.3	8.0	420.0	108.2	26	18	69.23%	128.6
1984	63.1	7.0	352.0	76.3	27	16	59.26%	95.9
1985	128.0	6.0	462.0	137.7	24	16	66.67%	183.1
1986	98.0	6.0	456.0	121.6	22	16	72.73%	129.3
1987	72.1	16.0	542.0	117.0	23	15	65.22%	100.3
1988	58.7	4.0	756.0	151.5	24	10	41.67%	123.2
1989	48.3	3.0	496.0	104.4	21	7	33.33%	114.4
JAN (80-89)	13.3	3.0	21.0	5.2	20	0	0.00%	
FEB (80-89)	12.7	4.0	32.0	7.2	16	1	6.25%	32.0
MARCH (80-89)	32.0	6.0	178.0	45.0	24	6	25.00%	86.8
APRIL (80-89)	273.6	4.0	756.0	193.0	23	21	91.30%	298.3
MAY (80-89)	87.4	13.0	356.0	82.8	19	16	84.21%	100.7
JUNE (80-89)	90.9	13.0	194.0	58.9	20	19	95.00%	95.0
JULY (80-89)	119.4	26.0	462.0	124.0	22	22	100.00%	119.4
AUG (80-89)	56.2	6.0	350.0	71.4	20	16	80.00%	66.8
SEPT (80-89)	44.4	16.0	118.0	23.4	21	17	80.95%	50.2
OCT (80-89)	50.2	8.0	392.0	79.7	22	12	54.55%	78.8
NOV (80-89)	27.1	10.0	83.0	19.7	19	6	31.58%	47.7
DEC (80-89)	14.4	6.0	24.0	5.8	14	0	0.00%	

FIGURE A35: Total suspended solids in the Red River, at site WQ450 at the Lockport Bridge.

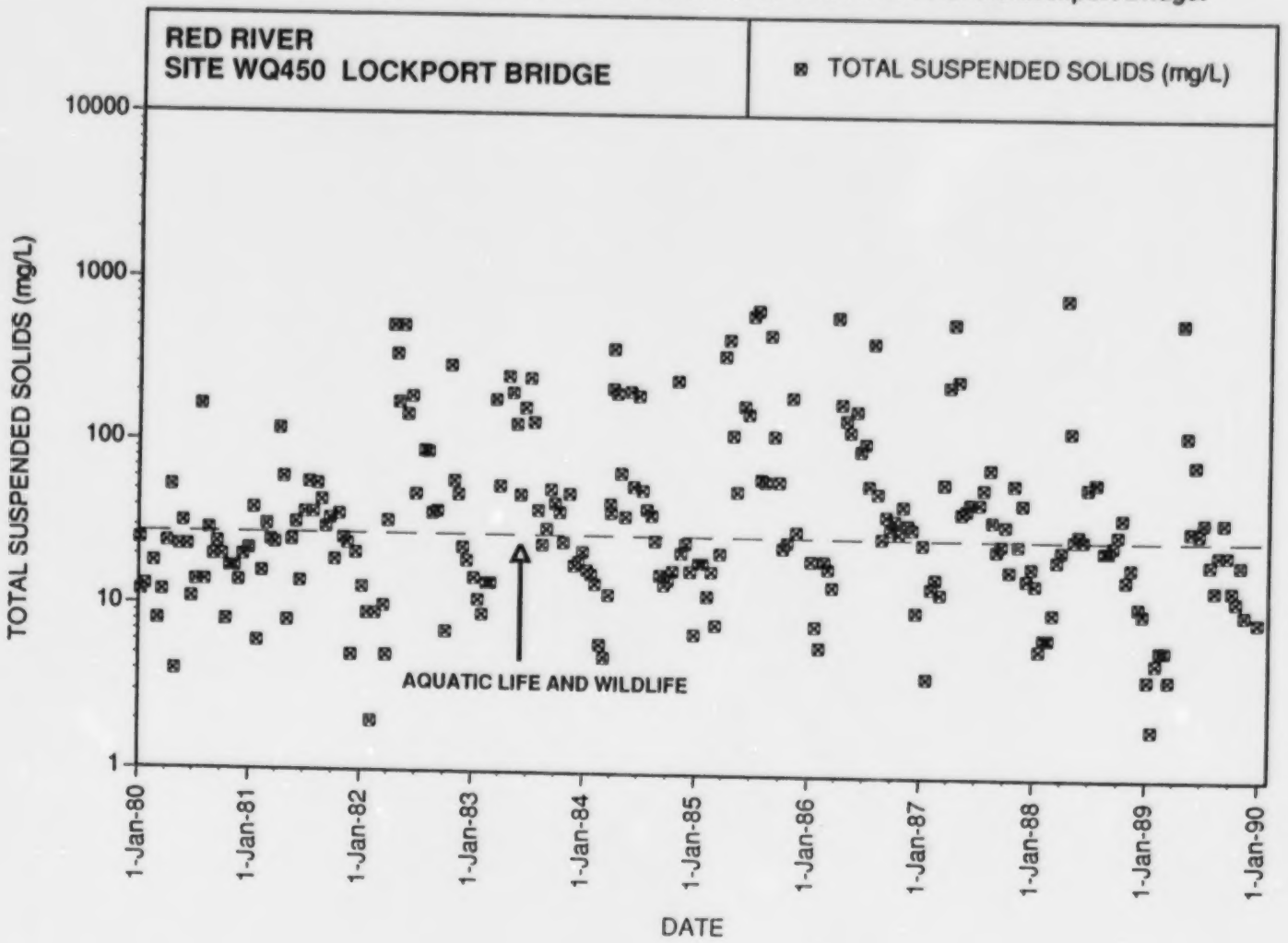


TABLE A29: Summary statistics and exceedence of the total suspended solids objective for aquatic life and wildlife at site WQ450 at the Lockport Bridge on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: TOTAL SUSPENDED SOLIDS
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 25. (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	74.5	2.0	812.0	126.6	248	132	53.23%	126.8
1980	24.7	4.0	165.0	30.2	26	4	15.38%	69.8
1981	32.9	5.0	118.0	23.0	25	14	56.00%	45.4
1982	113.0	2.0	516.0	154.1	24	15	62.50%	174.3
1983	73.1	9.0	252.0	77.4	25	15	60.00%	110.5
1984	70.4	5.0	380.0	94.7	29	15	51.72%	122.6
1985	149.5	8.0	666.0	198.4	25	16	64.00%	224.3
1986	100.0	6.0	612.0	144.4	23	18	78.26%	124.0
1987	72.0	4.0	570.0	120.2	25	17	68.00%	98.6
1988	62.3	6.0	812.0	161.8	24	11	45.83%	118.2
1989	49.6	2.0	584.0	122.5	22	7	31.82%	131.3
JAN (80-89)	14.2	2.0	39.0	9.1	19	2	10.53%	32.5
FEB (80-89)	12.1	2.0	31.0	6.8	19	1	5.26%	31.0
MARCH (80-89)	34.6	4.0	234.0	53.7	26	7	26.92%	92.0
APRIL (80-89)	288.9	4.0	812.0	221.3	22	20	90.91%	316.4
MAY (80-89)	99.1	8.0	516.0	119.2	19	16	84.21%	114.1
JUNE (80-89)	85.1	11.0	196.0	64.3	21	18	85.71%	96.6
JULY (80-89)	145.3	14.0	666.0	190.2	21	19	90.48%	158.8
AUG (80-89)	58.5	14.0	472.0	96.6	21	15	71.43%	73.7
SEPT (80-89)	35.7	14.0	114.0	21.6	20	14	70.00%	42.4
OCT (80-89)	46.1	7.0	294.0	73.6	22	9	40.91%	89.1
NOV (80-89)	37.5	10.0	196.0	39.6	20	10	50.00%	55.7
DEC (80-89)	15.9	5.0	32.0	7.0	18	1	5.56%	32.0

FIGURE A36: Total suspended solids in the Red river, at site WQ142 at Selkirk.

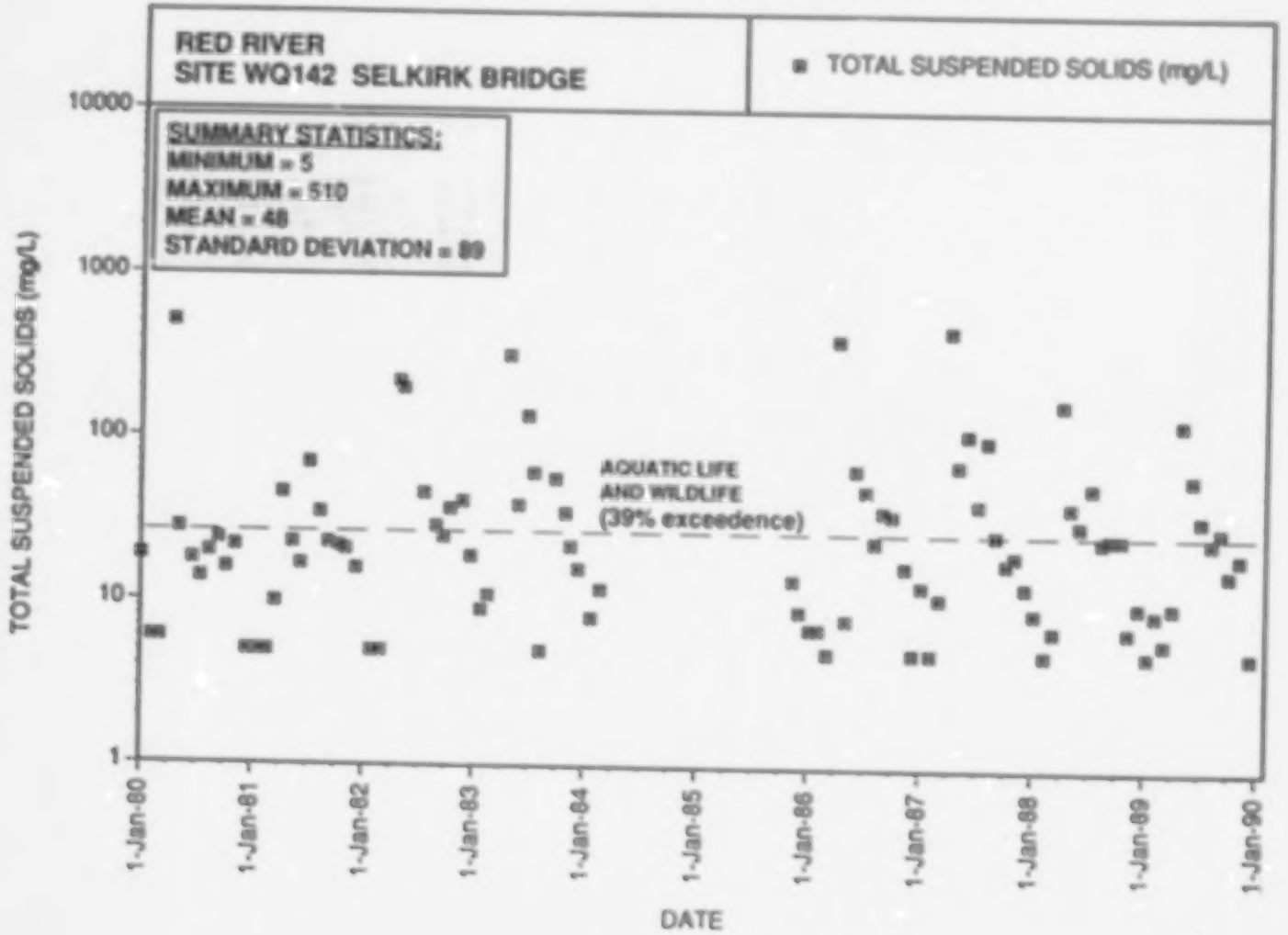


TABLE A30: Trend analysis and paired t-test results on total suspended solids data.

TREND ANALYSIS RESULTS: TOTAL SUSPENDED SOLIDS. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.03	0.023	*	DECREASING	183
WQ451 HEADINGLEY	0.00	0.710	N/S	DECREASING	286
WQ452 WEST PERIMETER	-	-	-	-	-
WQ453 MAIN STREET BRIDGE	0.00	0.793	N/S	DECREASING	273
RED RIVER SITES:					
WQ067 SOUTH GATE OF FLOODWAY	0.00	0.463	N/S	DECREASING	123
WQ445 FLOODWAY CONTROL	0.00	0.843	N/S	DECREASING	294
WQ576 FORT GARY BRIDGE	-	-	-	-	-
WQ447 NORWOOD BRIDGE	-	-	-	-	-
WQ448 REDWOOD BRIDGE	-	-	-	-	-
WQ449 NORTH PERIMETER	0.00	0.767	N/S	INCREASING	260
WQ450 LOCKPORT BRIDGE	0.00	0.873	N/S	INCREASING	292
WQ142 SELKIRK	0.01	0.134	N/S	DECREASING	224

PAIRED T-TEST RESULTS: TOTAL SUSPENDED SOLIDS UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.013	*	27.8	76
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.070	N/S	34.4	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.478	N/S	-14.9	78

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
- indicates insufficient data to perform analysis

FIGURE A37: Total dissolved solids in the Assiniboine River, at site WQ018 at Headingley.

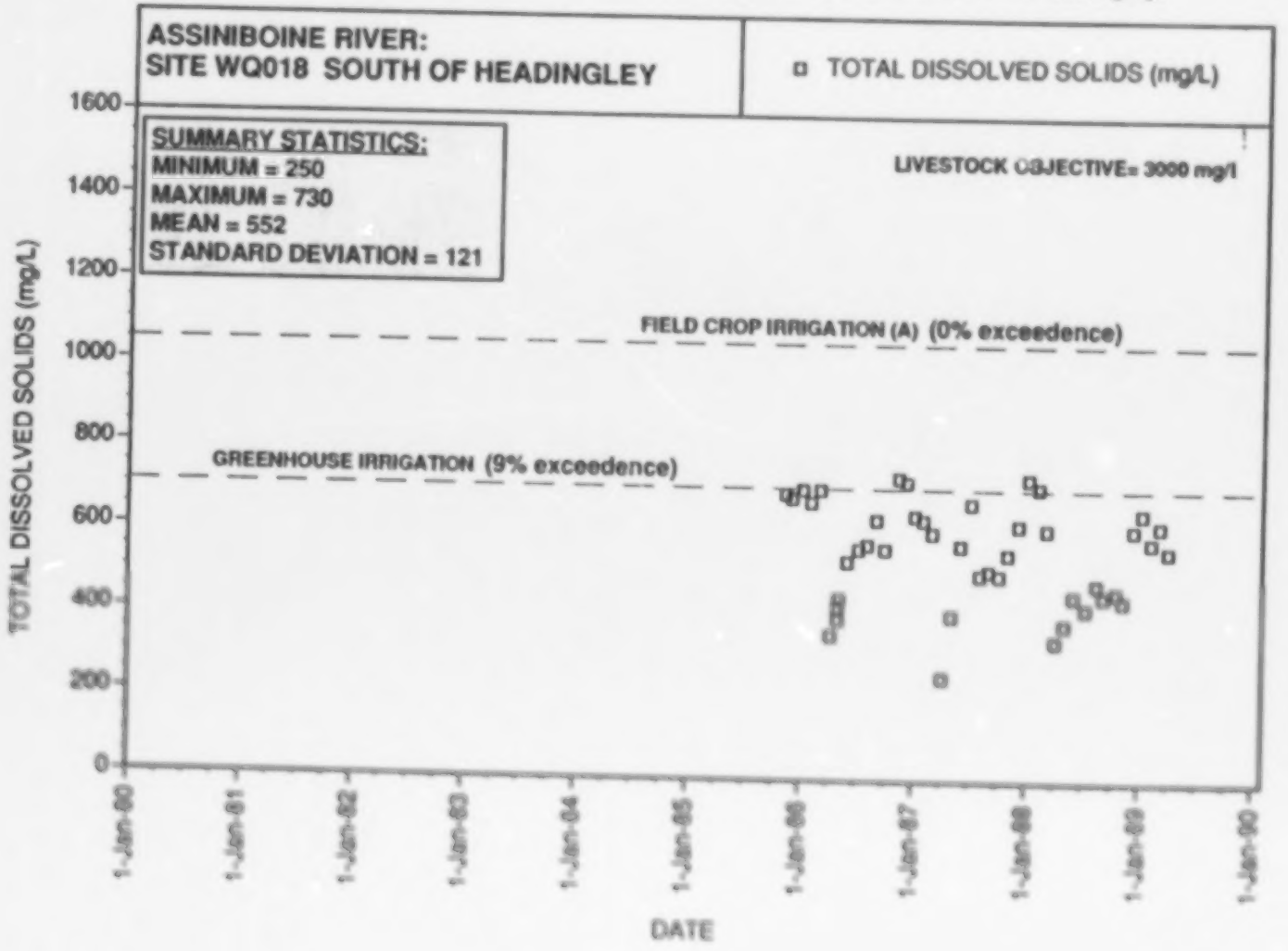


FIGURE A38: Total dissolved solids in the Red River, at site WQ367 at the south gate of the Floodway.

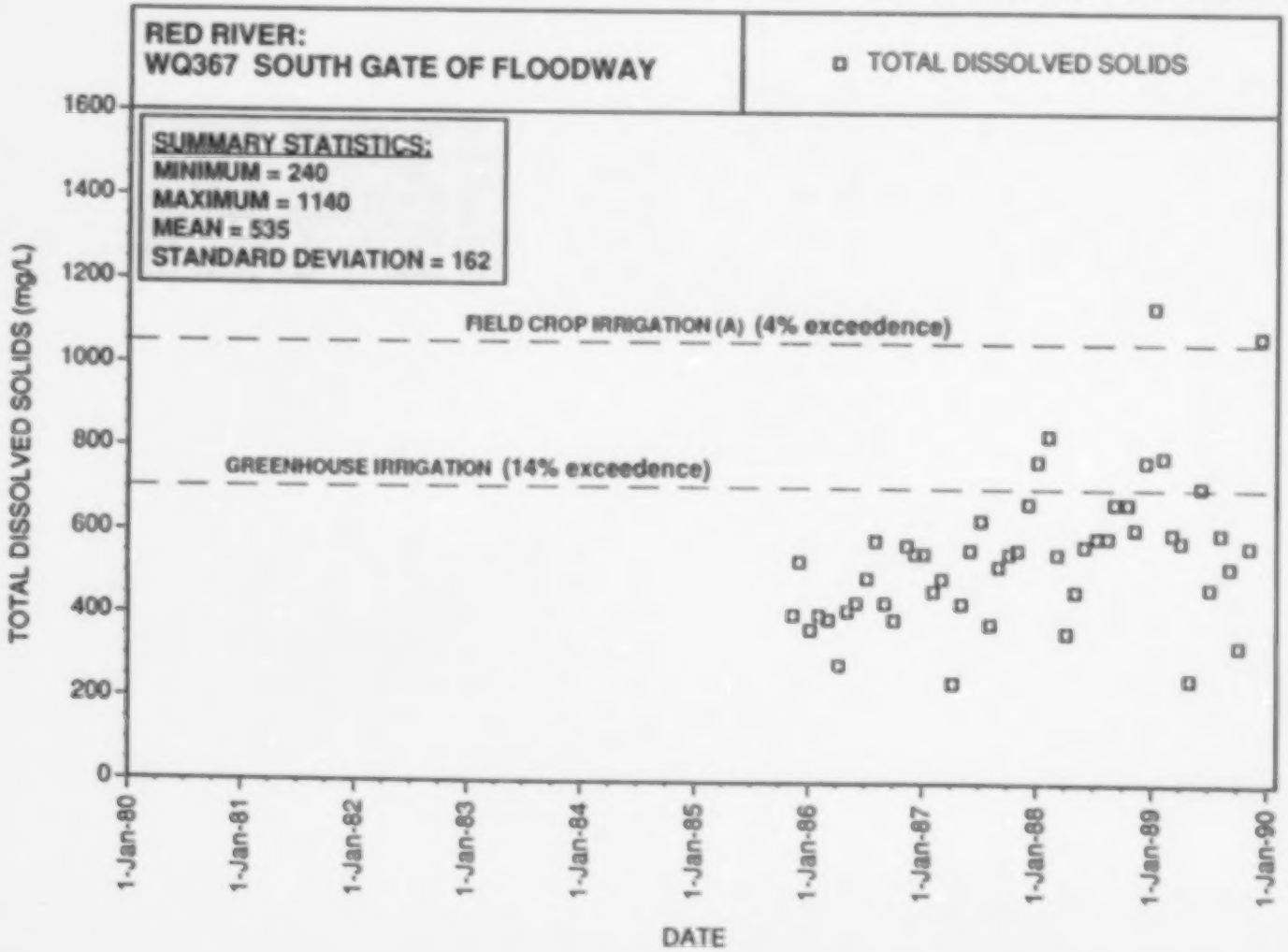


FIGURE A39: Total dissolved solids in the Red River, at site WQ142 at Selkirk.

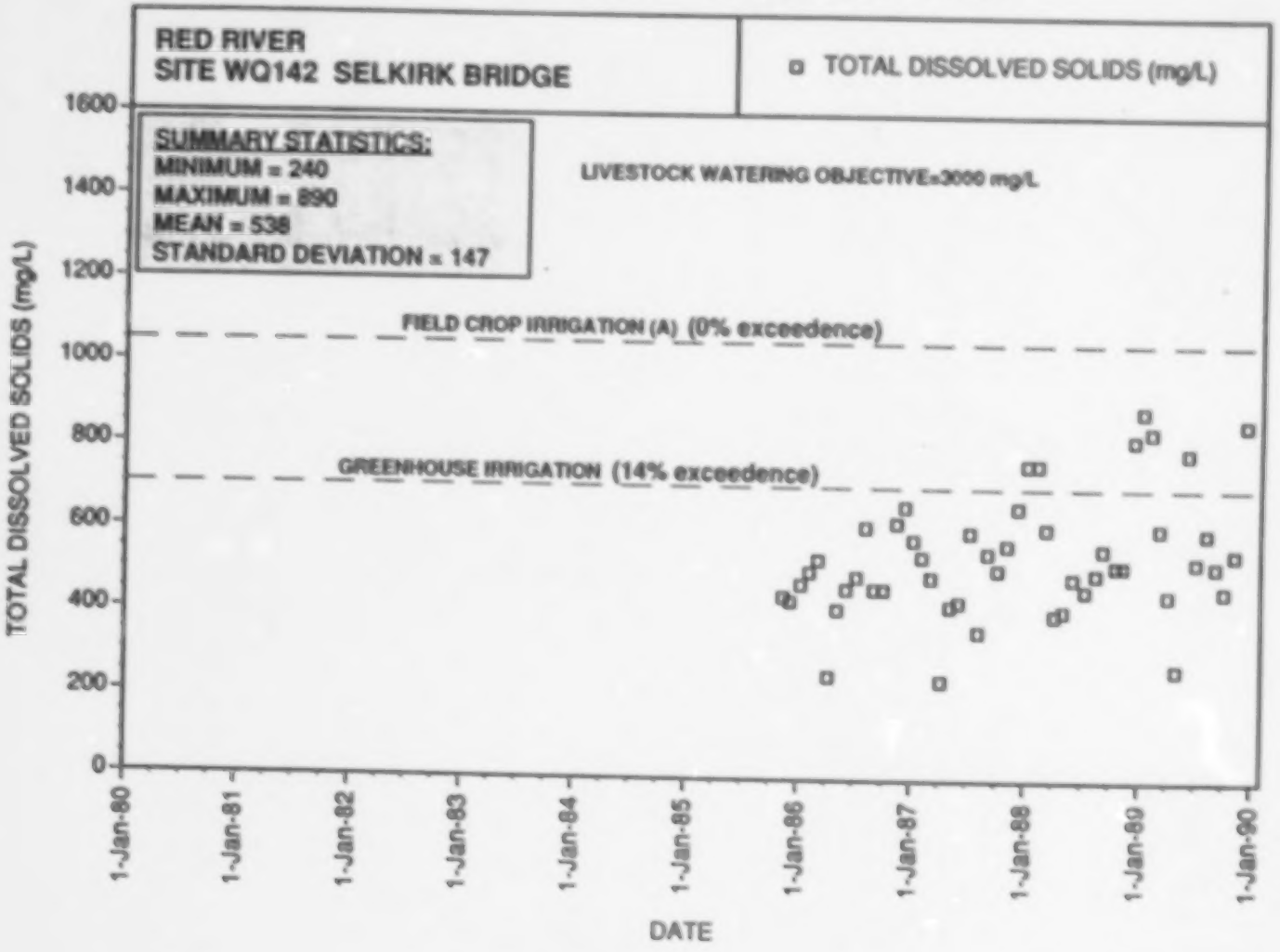


TABLE A31: Trend analysis and paired t-test results on total dissolved solids data.

TREND ANALYSIS RESULTS: TOTAL DISSOLVED SOLIDS. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.12	0.000 **	DECREASING	127
WQ451 HEADINGLEY	-	- -	-	-
WQ452 WEST PERIMETER	-	- -	-	-
WQ453 MAIN STREET BRIDGE	-	- -	-	-
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.16	0.011 *	INCREASING	49
WQ445 FLOODWAY CONTROL	-	- -	-	-
WQ576 FORT GARY BRIDGE	-	- -	-	-
WQ447 NORWOOD BRIDGE	-	- -	-	-
WQ448 REDWOOD BRIDGE	-	- -	-	-
WQ449 NORTH PERIMETER	-	- -	-	-
WQ450 LOCKPORT BRIDGE	-	- -	-	-
WQ142 SELKIRK	0.00	0.568 N/S	INCREASING	133

PAIRED T-TEST RESULTS: TOTAL DISSOLVED SOLIDS UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1986-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.150 N/S	26.7	41
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.741 N/S	3.78	48
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.535 N/S	15.8	41

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
- indicates insufficient data to perform analysis

FIGURE A40: True colour of the Assiniboine River, at site WQ018 at Headingley.

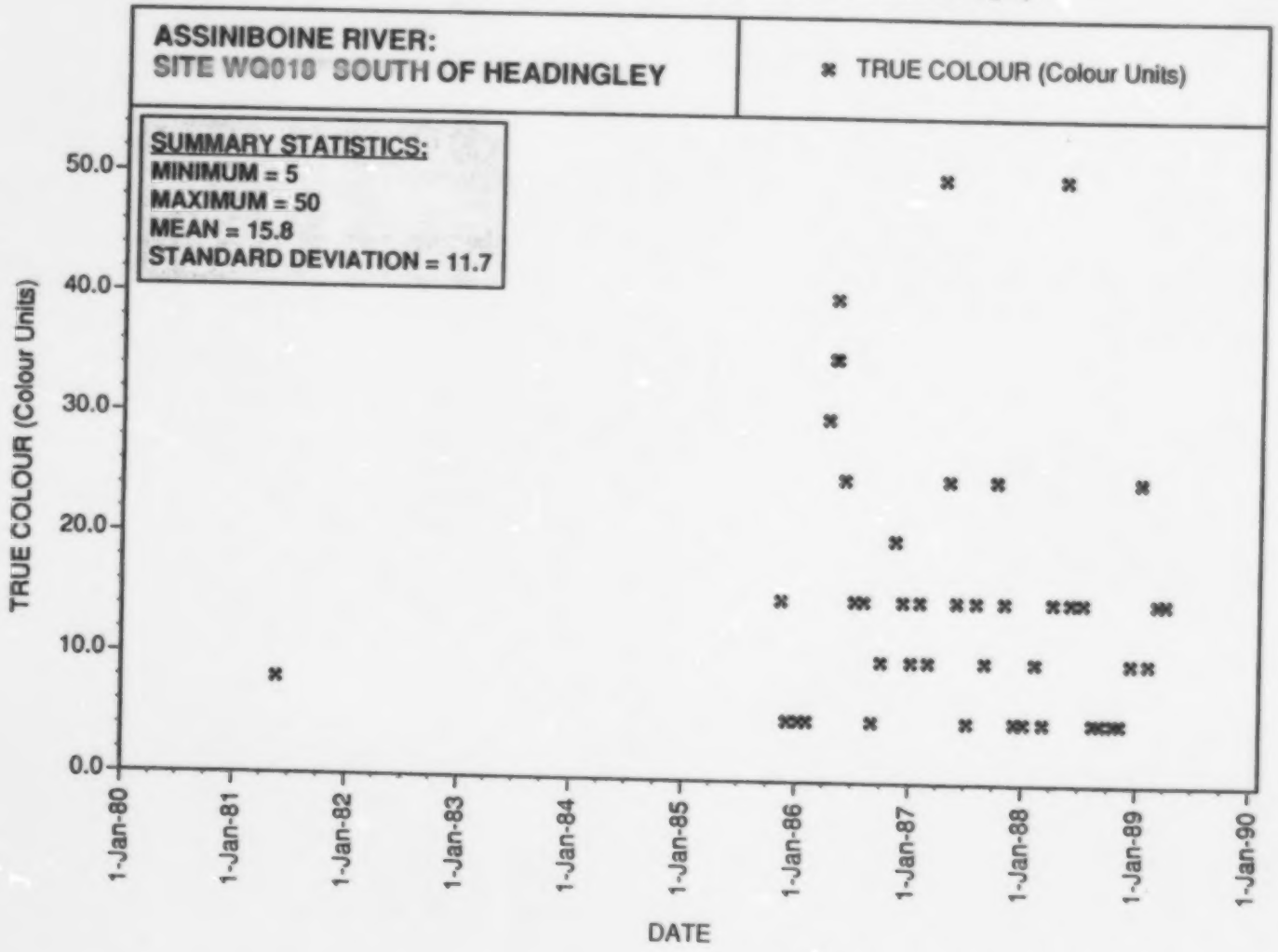


FIGURE A41: True colour in the Red River, at site WQ367 at the south gate of the Floodway.

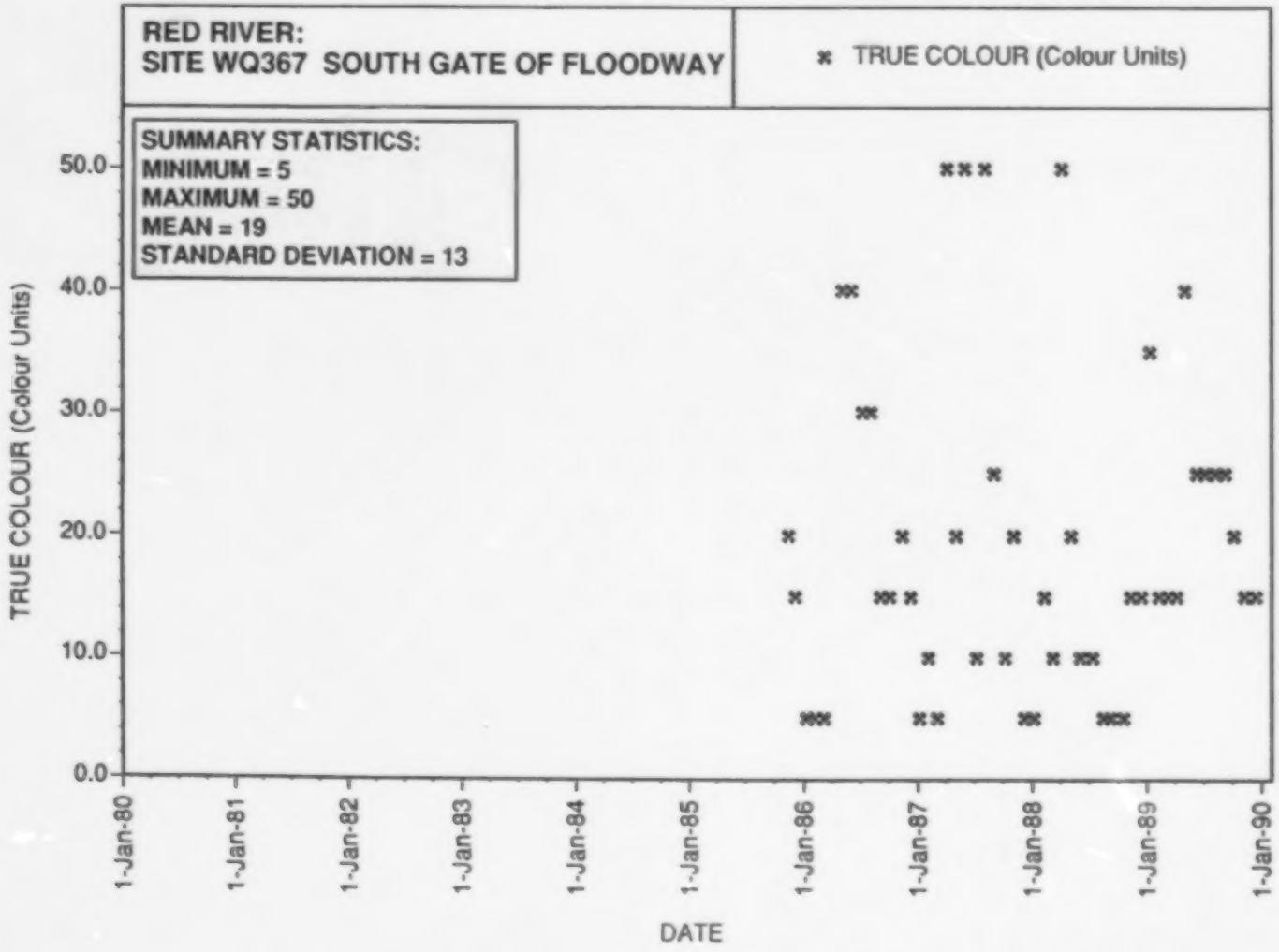


FIGURE A42: True colour in the Red River, at site WQ142 at Selkirk.

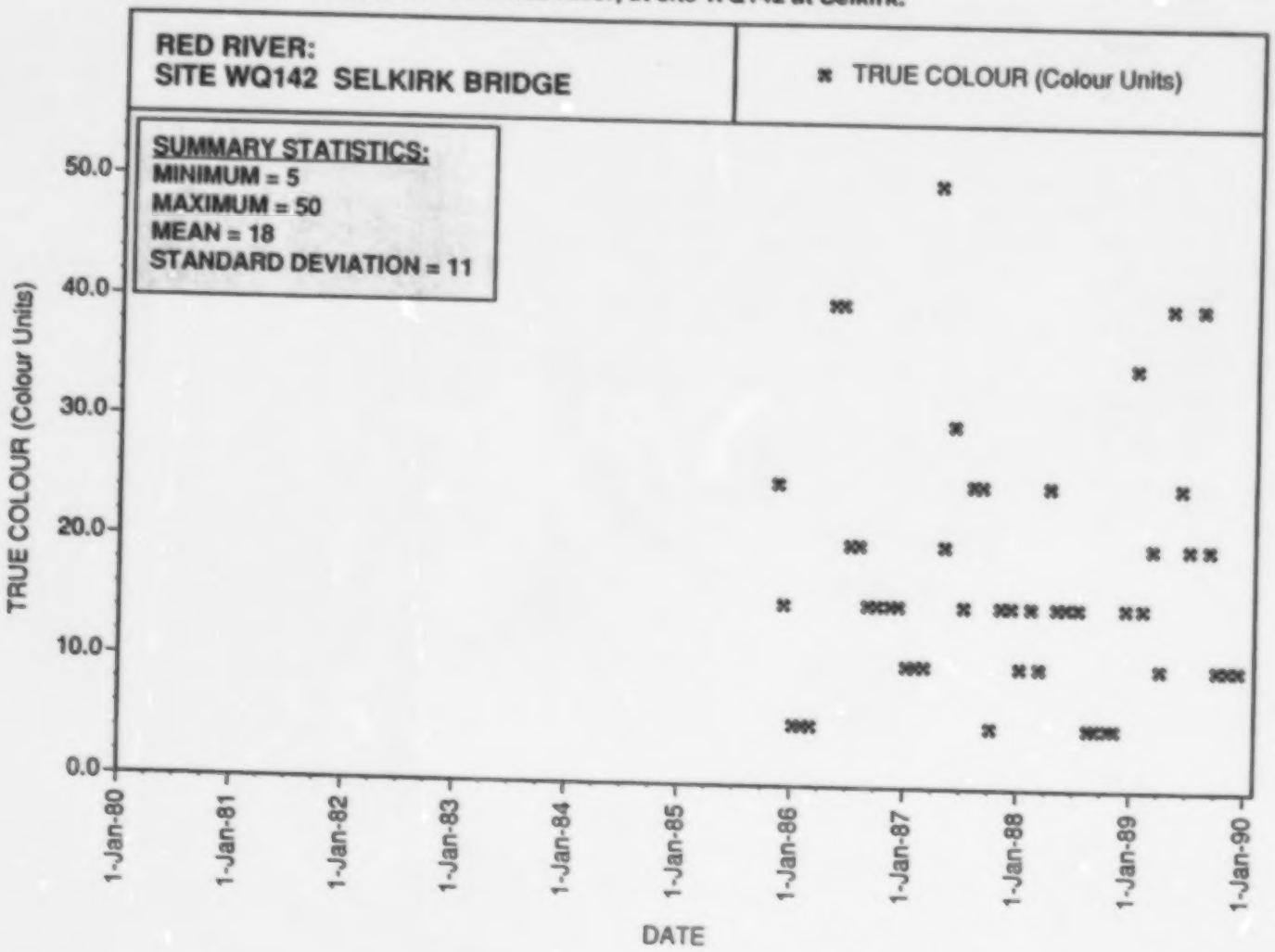


TABLE A32: Trend analysis and paired t-test results on true colour data.

TREND ANALYSIS RESULTS: TRUE COLOUR. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.01	0.648 N/S	DECREASING	44
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.00	0.991 N/S	INCREASING	49
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.00	0.906 N/S	DECREASING	49

PAIRED T-TEST RESULTS: TRUE COLOUR DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1986-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (COLOUR UNITS)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.089 N/S	-2.5	39
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.107 N/S	1.77	47
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.028 *	-4.38	39

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

TABLE A33: Trend analysis and paired t-test results on temperature data.

TREND ANALYSIS RESULTS: TEMPERATURE. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.01	0.207 N/S	DECREASING	169
WQ451 HEADINGLEY	0.00	0.313 N/S	INCREASING	288
WQ452 WEST PERIMETER	0.01	0.220 N/S	INCREASING	295
WQ453 MAIN STREET BRIDGE	0.01	0.137 N/S	INCREASING	287
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.00	0.992 N/S	INCREASING	122
WQ445 FLOODWAY CONTROL	0.01	0.122 N/S	DECREASING	308
WQ576 FORT GARY BRIDGE	0.01	0.231 N/S	INCREASING	190
WQ447 NORWOOD BRIDGE	0.00	0.272 N/S	INCREASING	281
WQ448 REDWOOD BRIDGE	0.00	0.261 N/S	INCREASING	285
WQ449 NORTH PERIMETER	0.01	0.073 N/S	INCREASING	298
WQ450 LOCKPORT BRIDGE	0.00	0.291 N/S	INCREASING	298
WQ142 SELKIRK	0.00	0.853 N/S	INCREASING	199

PAIRED T-TEST RESULTS: TEMPERATURE DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (oC)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.250 N/S	-0.271	76
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.018 *	-0.433	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.434 N/S	0.205	77

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)
~ indicates insufficient data to perform analysis

FIGURE A43: Conductivity levels in the Assiniboine River, at site WQ018 at Headingley.

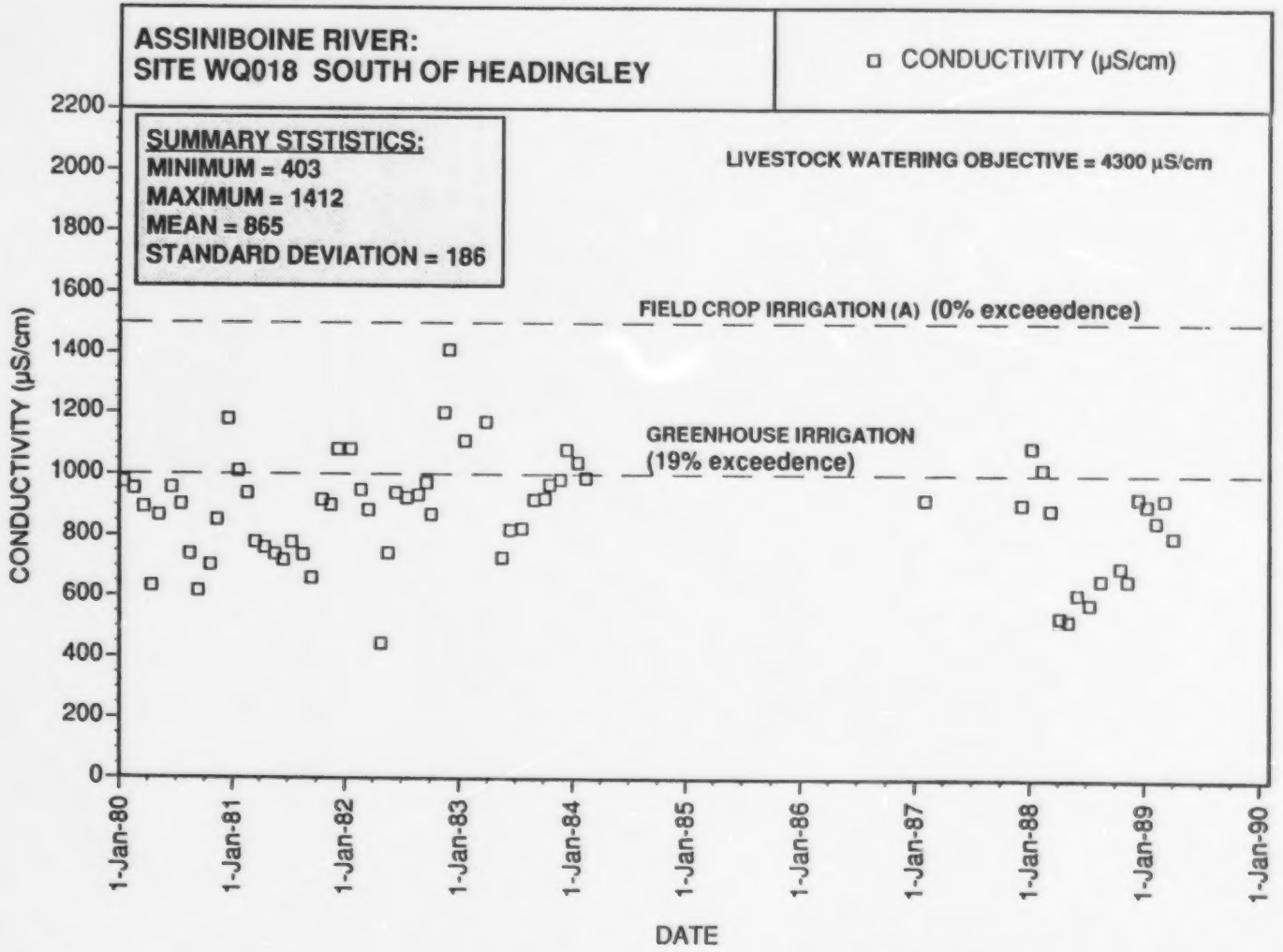


FIGURE A44: Conductivity level in the Red River, at site WQ367 at the south gate of the Floodway.

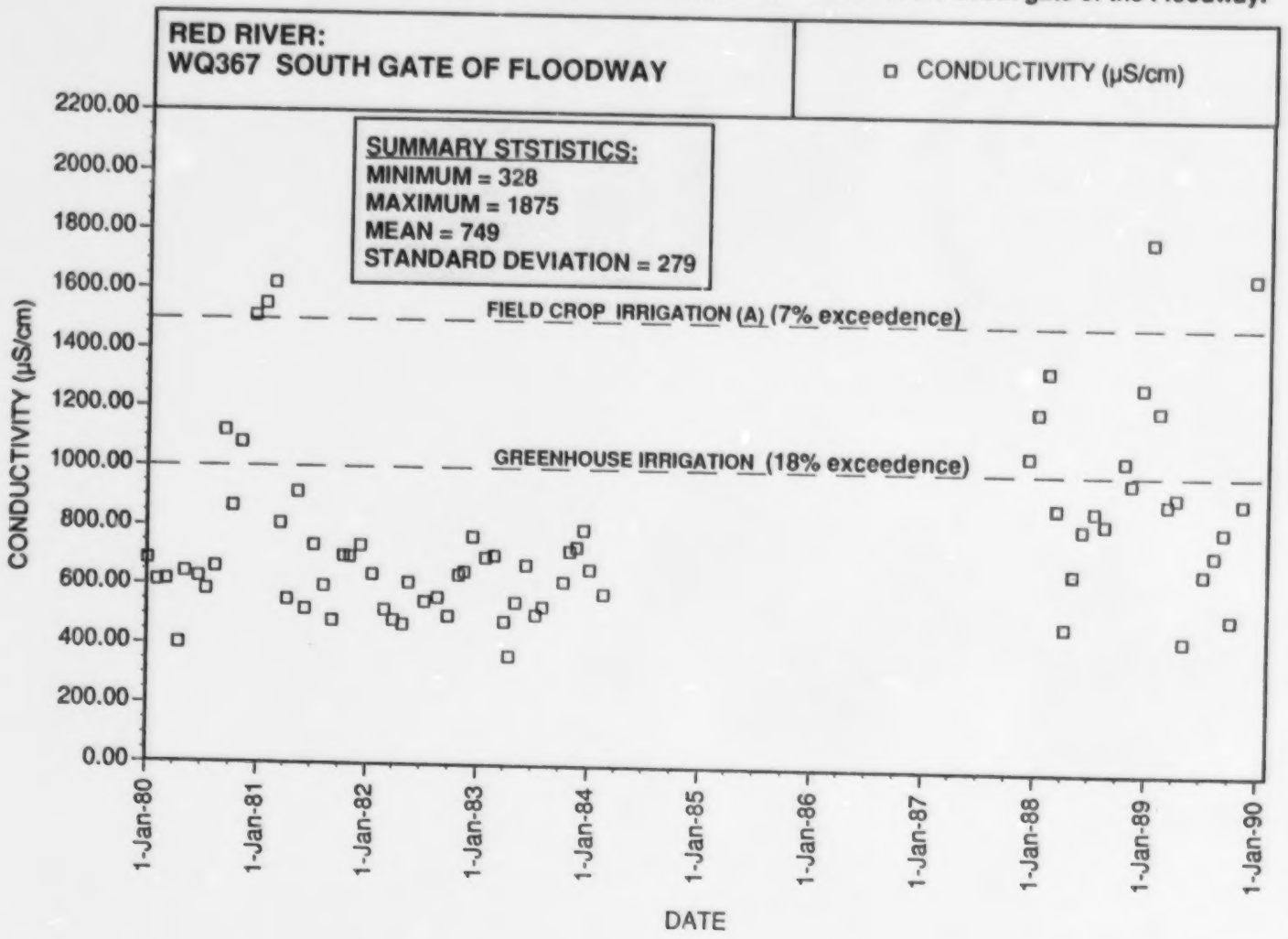


FIGURE A45: Conductivity levels in the Red River, at site WQ142 at Selkirk.

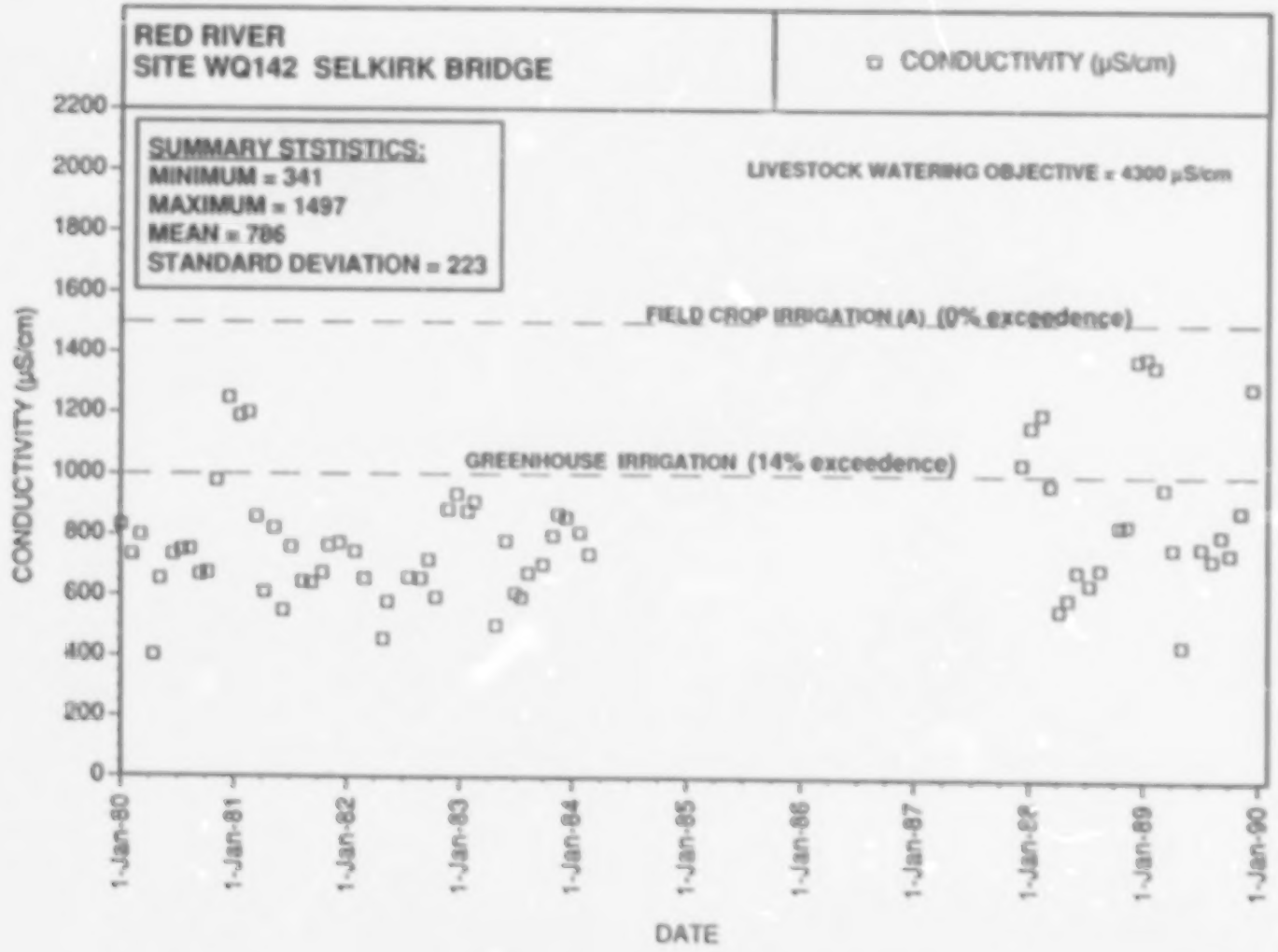


TABLE A34: Trend analysis and paired t-test results on conductivity data.

TREND ANALYSIS RESULTS: CONDUCTIVITY. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.01	0.179	N/S	DECREASING	169
WQ451 HEADINGLEY	~	~		~	~
WQ452 WEST PERIMETER	~	~		~	~
WQ453 MAIN STREET BRIDGE	~	~		~	~
RED RIVER SITES:					
WQ367 SOUTH GATE OF FLOODWAY	0.04	0.027	*	INCREASING	119
WQ445 FLOODWAY CONTROL	~	~		~	~
WQ576 FORT GARY BRIDGE	~	~		~	~
WQ447 NORWOOD BRIDGE	~	~		~	~
WQ448 REDWOOD BRIDGE	~	~		~	~
WQ449 NORTH PERIMETER	~	~		~	~
WQ450 LOCKPORT BRIDGE	~	~		~	~
WQ142 SELKIRK	0.03	0.018	*	INCREASING	202

PAIRED T-TEST RESULTS: CONDUCTIVITY DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (µS/cm)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.163	N/S	42.2	5[illegible]
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.866	N/S	-3.36	63
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.203	N/S	61.4	52

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)
~ indicates insufficient data to perform analysis

FIGURE A46: Ammonia and un-ionized ammonia concentrations in the Assiniboine River, at site WQ018 at Headingley.

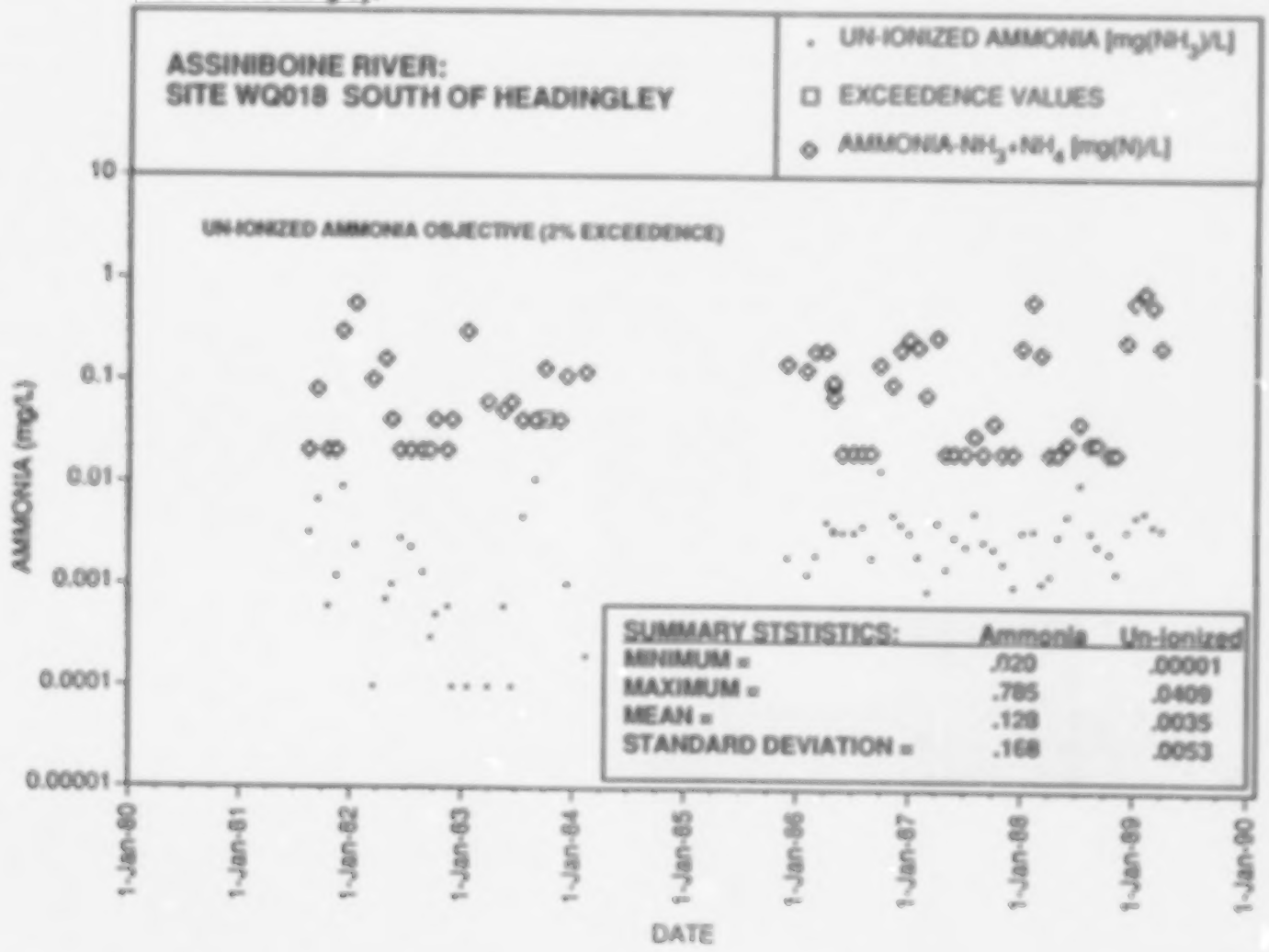


FIGURE A47: Ammonia and un-ionized ammonia concentrations in the Assiniboine River, at site WQ451 at Headingley.

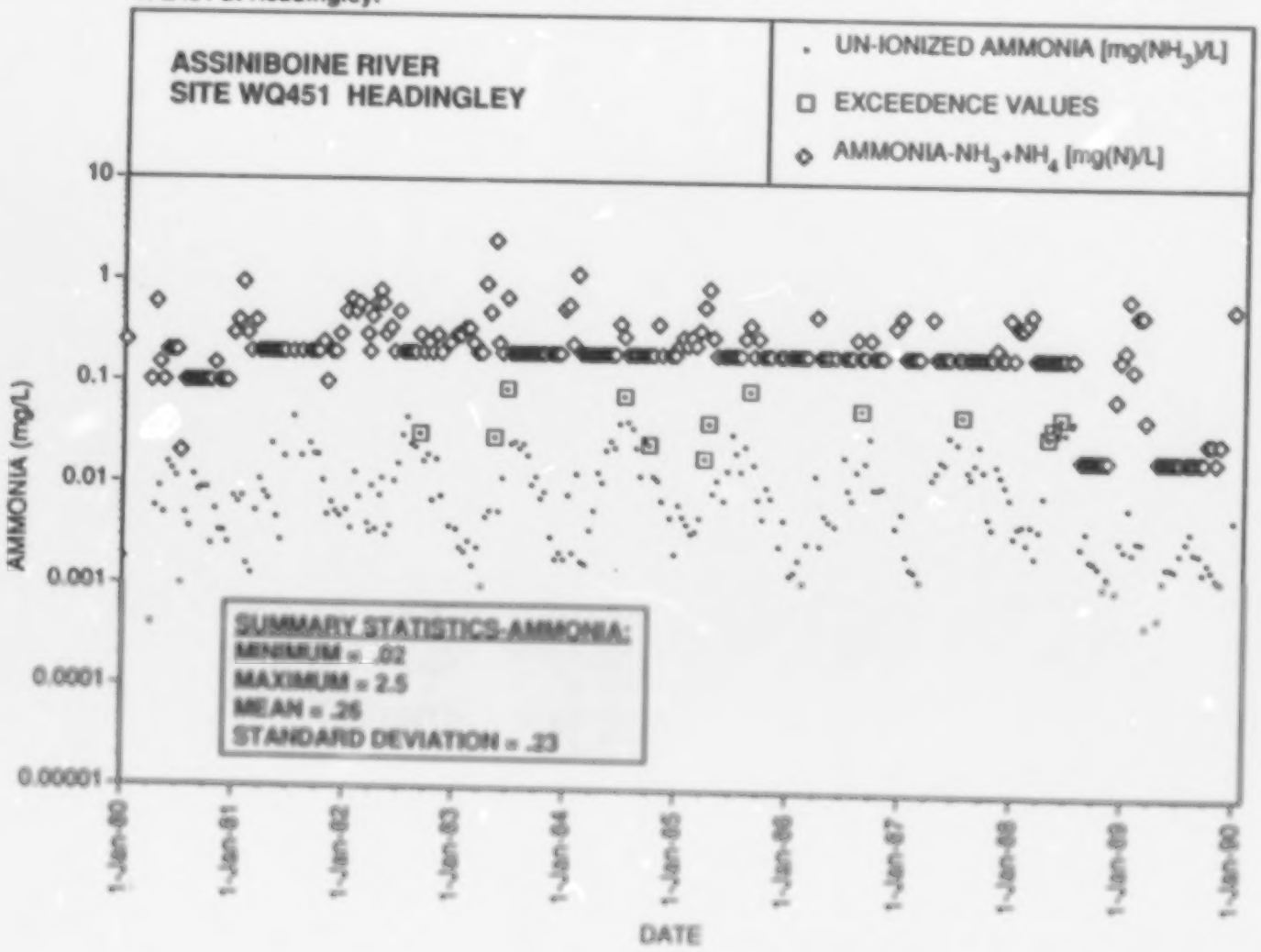


TABLE A35: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ451 at Headingley on the Assiniboine River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERATURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.0123	0.0004	0.0890	0.0142	233	13	5.6%	0.0490
1980	0.0064	0.0004	0.0154	0.0042	21	0	0.0%	
1981	0.0117	0.0013	0.0449	0.0103	22	0	0.0%	
1982	0.0132	0.0032	0.0449	0.0107	25	1	4.0%	0.0312
1983	0.0126	0.0010	0.0879	0.0179	26	2	7.7%	0.0585
1984	0.0183	0.0017	0.0765	0.0172	25	2	8.0%	0.0510
1985	0.0154	0.0027	0.0890	0.0185	24	3	12.5%	0.0500
1986	0.0112	0.0012	0.0586	0.0132	21	1	4.8%	0.0586
1987	0.0150	0.0013	0.0531	0.0121	23	1	4.3%	0.0531
1988	0.0145	0.0011	0.0516	0.0182	24	3	12.5%	0.0419
1989	0.0026	0.0005	0.0070	0.0015	22	0	0.0%	
JAN (80-89)	0.0042	0.0014	0.0081	0.0022	20	0	0.0%	
FEB (80-89)	0.0040	0.0012	0.0130	0.0037	17	0	0.0%	
MARCH (80-89)	0.0038	0.0005	0.0109	0.0027	19	0	0.0%	
APRIL (80-89)	0.0106	0.0004	0.0420	0.0100	22	3	13.6%	0.0314
MAY (80-89)	0.0154	0.0014	0.0407	0.0120	19	2	10.5%	0.0349
JUNE (80-89)	0.0206	0.0018	0.0879	0.0217	19	2	10.5%	0.0698
JULY (80-89)	0.0278	0.0010	0.0765	0.0200	21	2	9.5%	0.0648
AUG (80-89)	0.0220	0.0027	0.0890	0.0206	20	2	10.0%	0.0738
SEPT (80-89)	0.0150	0.0017	0.0315	0.0095	21	1	4.8%	0.0312
OCT (80-89)	0.0087	0.0012	0.0255	0.0063	22	1	4.5%	0.0255
NOV (80-89)	0.0069	0.0014	0.0177	0.0055	16	0	0.0%	
DEC (80-89)	0.0045	0.0011	0.0113	0.0026	17	0	0.0%	

FIGURE A48: Ammonia and un-ionized ammonia concentrations in the Assiniboine River, at site WQ453 at the Main Street Bridge.

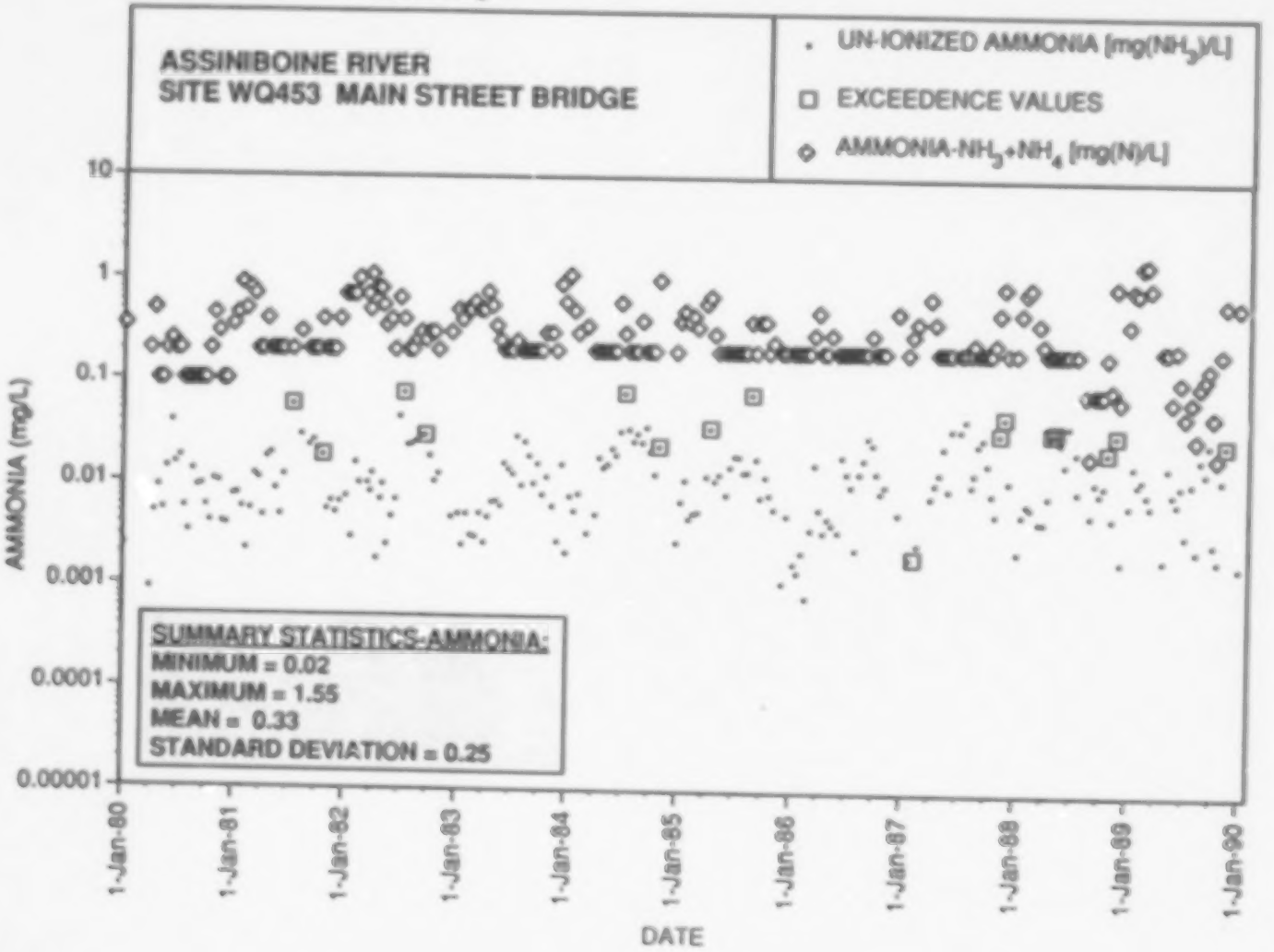


TABLE A36: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ453 at the Main Street Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERATURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.0136	0.0008	0.0765	0.0125	226	15	6.6%	0.0413
1980	0.0092	0.0009	0.0385	0.0080	21	0	0.0%	
1981	0.0140	0.0022	0.0569	0.0123	22	2	9.1%	0.0377
1982	0.0164	0.0018	0.0751	0.0162	24	2	8.3%	0.0520
1983	0.0094	0.0021	0.0285	0.0070	26	0	0.0%	
1984	0.0208	0.0027	0.0765	0.0164	21	2	9.5%	0.0499
1985	0.0142	0.0011	0.0758	0.0152	23	2	8.7%	0.0555
1986	0.0094	0.0008	0.0293	0.0079	23	0	0.0%	
1987	0.0184	0.0020	0.0471	0.0140	21	2	9.5%	0.0399
1988	0.0147	0.0019	0.0393	0.0117	23	4	17.4%	0.0306
1989	0.0105	0.0017	0.0268	0.0073	22	1	4.5%	0.0268
JAN (80-89)	0.0059	0.0014	0.0163	0.0039	19	0	0.0%	
FEB (80-89)	0.0058	0.0008	0.0156	0.0041	16	0	0.0%	
MARCH (80-89)	0.0074	0.0026	0.0160	0.0039	17	0	0.0%	
APRIL (80-89)	0.0100	0.0009	0.0352	0.0091	22	2	9.1%	0.0343
MAY (80-89)	0.0137	0.0025	0.0346	0.0085	19	1	5.3%	0.0346
JUNE (80-89)	0.0181	0.0036	0.0436	0.0127	20	0	0.0%	
JULY (80-89)	0.0253	0.0024	0.0765	0.0216	21	3	14.3%	0.0695
AUG (80-89)	0.0198	0.0025	0.0758	0.0156	20	1	5.0%	0.0758
SEPT (80-89)	0.0201	0.0076	0.0356	0.0086	21	1	4.8%	0.0288
OCT (80-89)	0.0118	0.0020	0.0232	0.0064	22	3	13.6%	0.0213
NOV (80-89)	0.0146	0.0027	0.0471	0.0135	15	4	26.7%	0.0348
DEC (80-89)	0.0053	0.0011	0.0153	0.0040	14	0	0.0%	

FIGURE A49: Ammonia and un-ionized ammonia concentrtions in the Red River, at site WQ367 at the south gate of the Floodway.

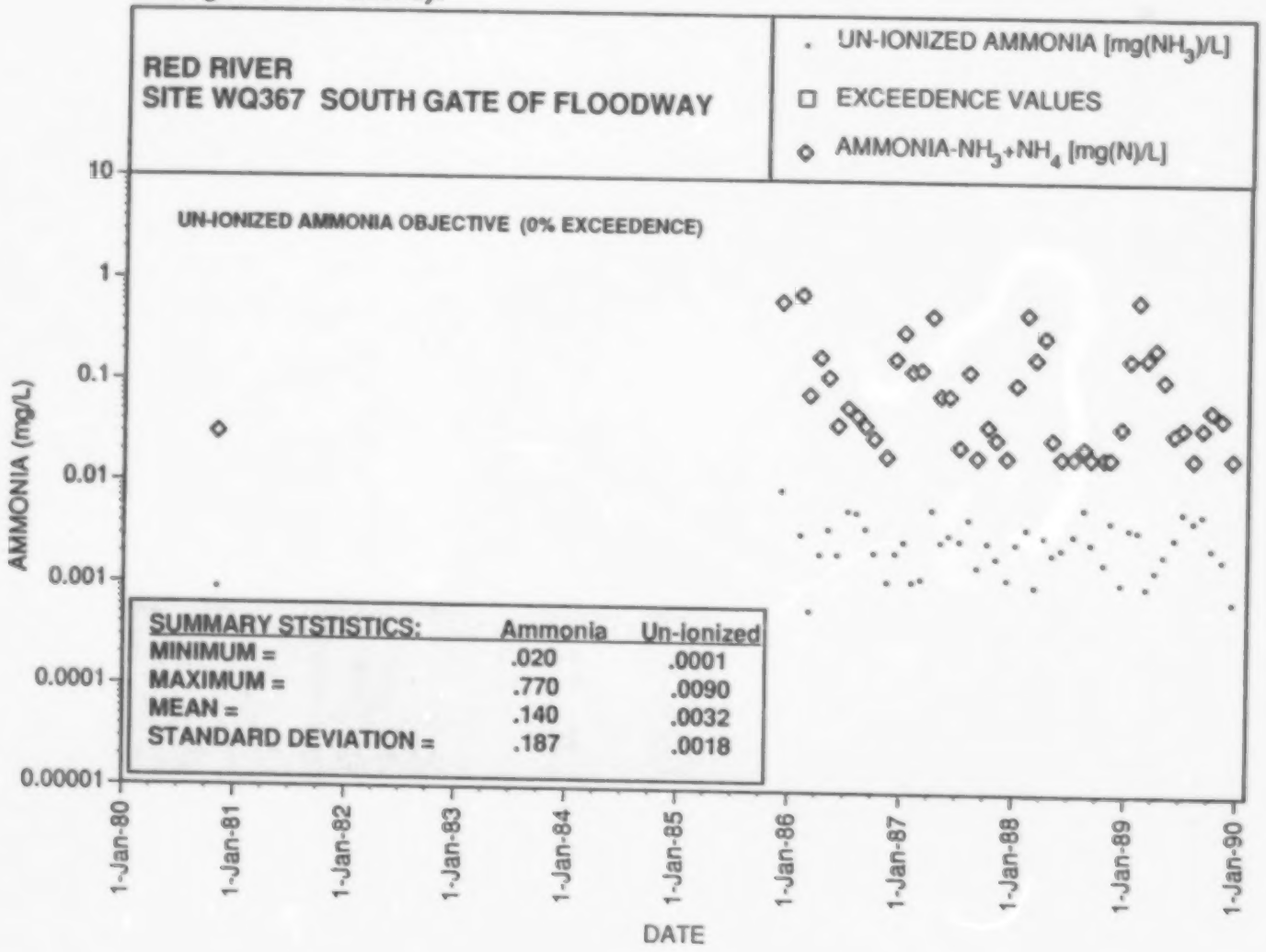


FIGURE A50: Ammonia and un-ionized ammonia concentrations in the Red River, at site WQ445 at the south Floodway control.

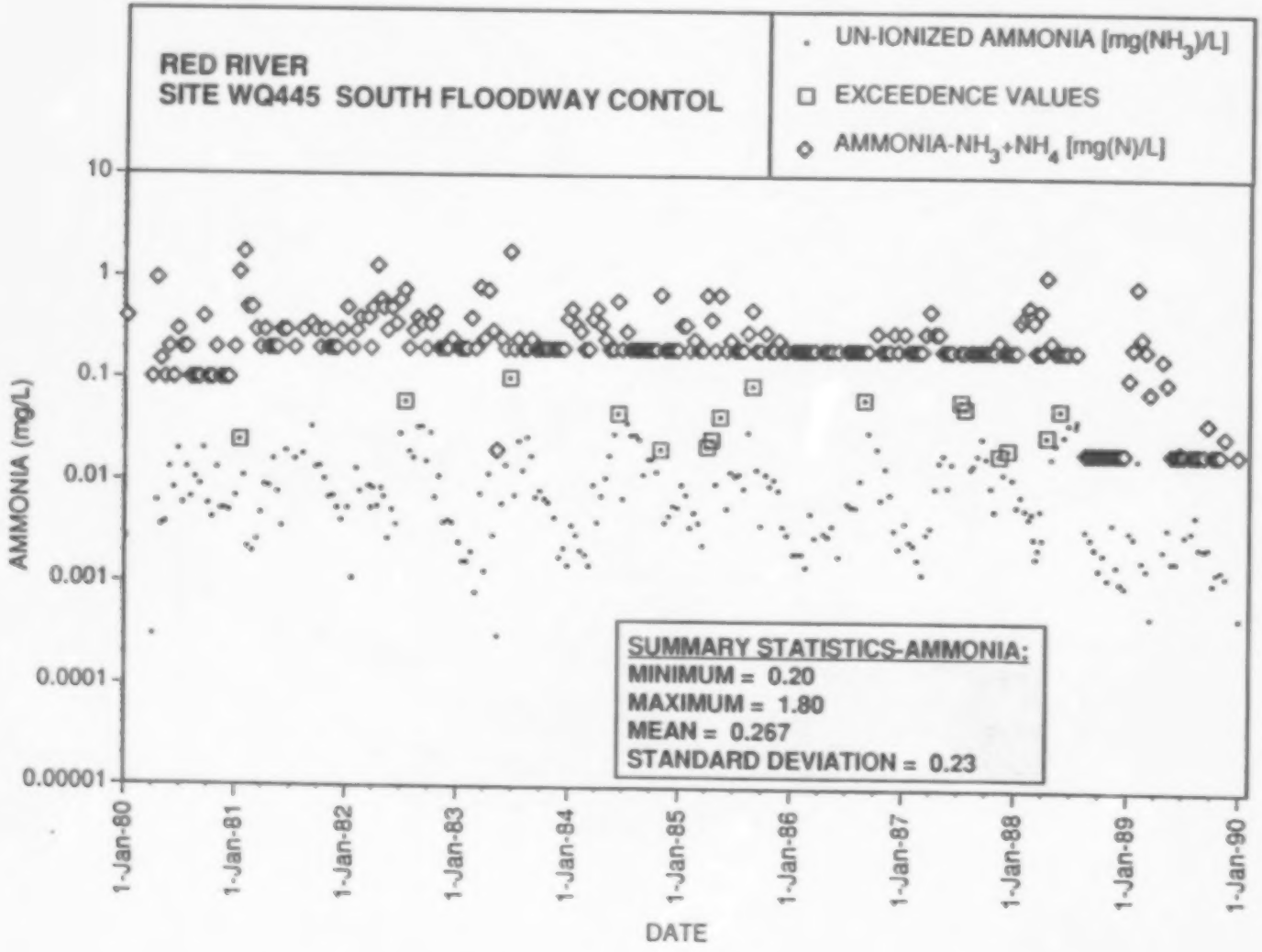


TABLE A37: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERAURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.0115	0.0003	0.1028	0.0140	243	16	6.58%	0.0464
1980	0.0081	0.0003	0.0202	0.0053	21	0	0.00%	
1981	0.0110	0.0020	0.0337	0.0080	22	1	4.55%	0.025
1982	0.0135	0.0011	0.0597	0.0135	26	1	3.85%	0.060
1983	0.0109	0.0003	0.1028	0.0200	26	1	3.85%	0.103
1984	0.0140	0.0015	0.0466	0.0122	26	2	7.69%	0.034
1985	0.0148	0.0024	0.0890	0.0183	25	4	16.00%	0.045
1986	0.0095	0.0015	0.0655	0.0145	22	1	4.55%	0.066
1987	0.0153	0.0013	0.0642	0.0152	25	4	16.00%	0.040
1988	0.0122	0.0010	0.0535	0.0154	28	2	7.14%	0.041
1989	0.0040	0.0005	0.0243	0.0057	22	0	0.00%	
JAN (80-89)	0.0060	0.0011	0.0245	0.0060	19	1	5.26%	0.025
FEB (80-89)	0.0040	0.0015	0.0131	0.0030	19	0	0.00%	
MARCH (80-89)	0.0040	0.0005	0.0093	0.0030	24	0	0.00%	
APRIL (80-89)	0.0100	0.0003	0.0292	0.0080	21	3	14.29%	0.026
MAY (80-89)	0.0140	0.0003	0.0535	0.0150	19	2	10.53%	0.049
JUNE (80-89)	0.0210	0.0018	0.1028	0.0240	19	2	10.53%	0.075
JULY (80-89)	0.0220	0.0033	0.0642	0.0190	21	3	14.29%	0.06
AUG (80-89)	0.0220	0.0025	0.0890	0.0210	20	2	10.00%	0.077
SEPT (80-89)	0.0150	0.0015	0.0339	0.0110	20	0	0.00%	
OCT (80-89)	0.0100	0.0011	0.0294	0.0070	22	1	4.55%	0.021
NOV (80-89)	0.0070	0.0013	0.0190	0.0050	21	1	4.76%	0.019
DEC (80-89)	0.0050	0.0005	0.0216	0.0049	18	1	5.56%	0.022

FIGURE A51: Ammonia and un-ionized ammonia concentrations in the Red River, at site WQ576 at the Fort Gary Bridge.

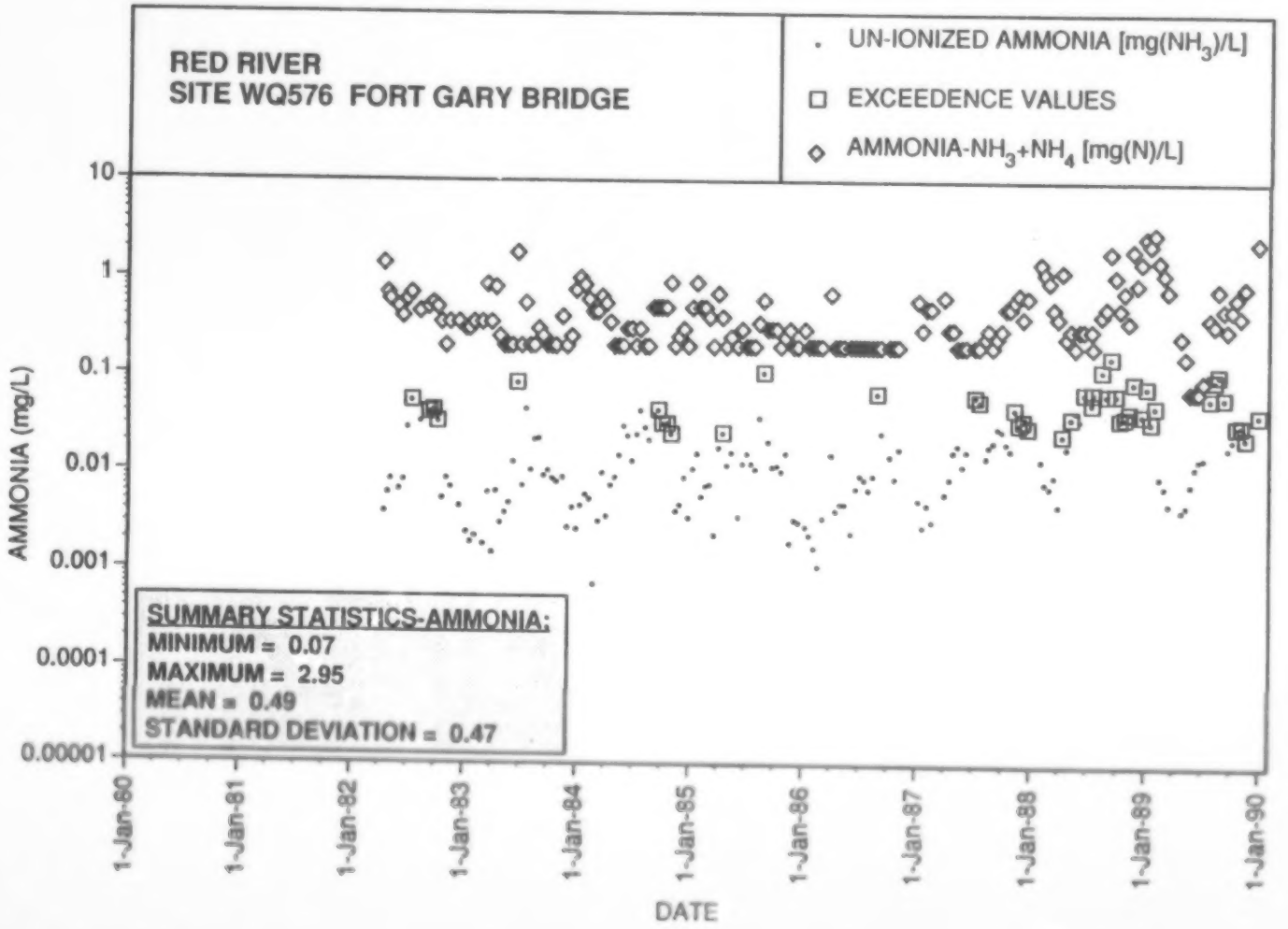


TABLE A38: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ576 at the Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERAURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	0.022	0.001	0.159	0.025	178	43	24.2%	0.055
1980								
1981								
1982	0.018	0.002	0.054	0.017	16	4	25.0%	0.043
1983	0.012	0.002	0.082	0.018	24	1	4.2%	0.082
1984	0.017	0.001	0.043	0.014	26	4	15.4%	0.033
1985	0.016	0.002	0.107	0.020	25	2	8.0%	0.066
1986	0.011	0.001	0.066	0.014	20	1	5.0%	0.066
1987	0.022	0.003	0.061	0.016	23	6	26.1%	0.043
1988	0.047	0.005	0.159	0.038	23	14	60.9%	0.064
1989	0.033	0.001	0.107	0.004	22	11	50.0%	0.056
JAN (82-89)	0.017	0.002	0.079	0.023	13	3	23.1%	0.054
FEB (82-89)	0.005	0.001	0.014	0.004	12	0	0.0%	
MARCH (82-89)	0.005	0.002	0.010	0.003	14	0	0.0%	
APRIL (82-89)	0.011	0.003	0.025	0.007	17	2	11.8%	0.025
MAY (82-89)	0.015	0.004	0.043	0.013	14	1	7.1%	0.037
JUNE (82-89)	0.021	0.002	0.082	0.023	16	2	12.5%	0.075
JULY (82-89)	0.032	0.007	0.068	0.023	17	6	35.3%	0.058
AUG (82-89)	0.048	0.009	0.116	0.038	16	6	37.5%	0.092
SEPT (82-89)	0.039	0.009	0.159	0.036	16	6	37.5%	0.069
OCT (82-89)	0.021	0.005	0.037	0.011	17	7	41.2%	0.032
NOV (82-89)	0.022	0.002	0.087	0.023	15	6	40.0%	0.044
DEC (82-89)	0.016	0.003	0.041	0.017	11	4	36.4%	0.036

FIGURE A52: Ammonia and un-ionized ammonia concentrations in the Red River, at site WQ449 at the north perimeter.

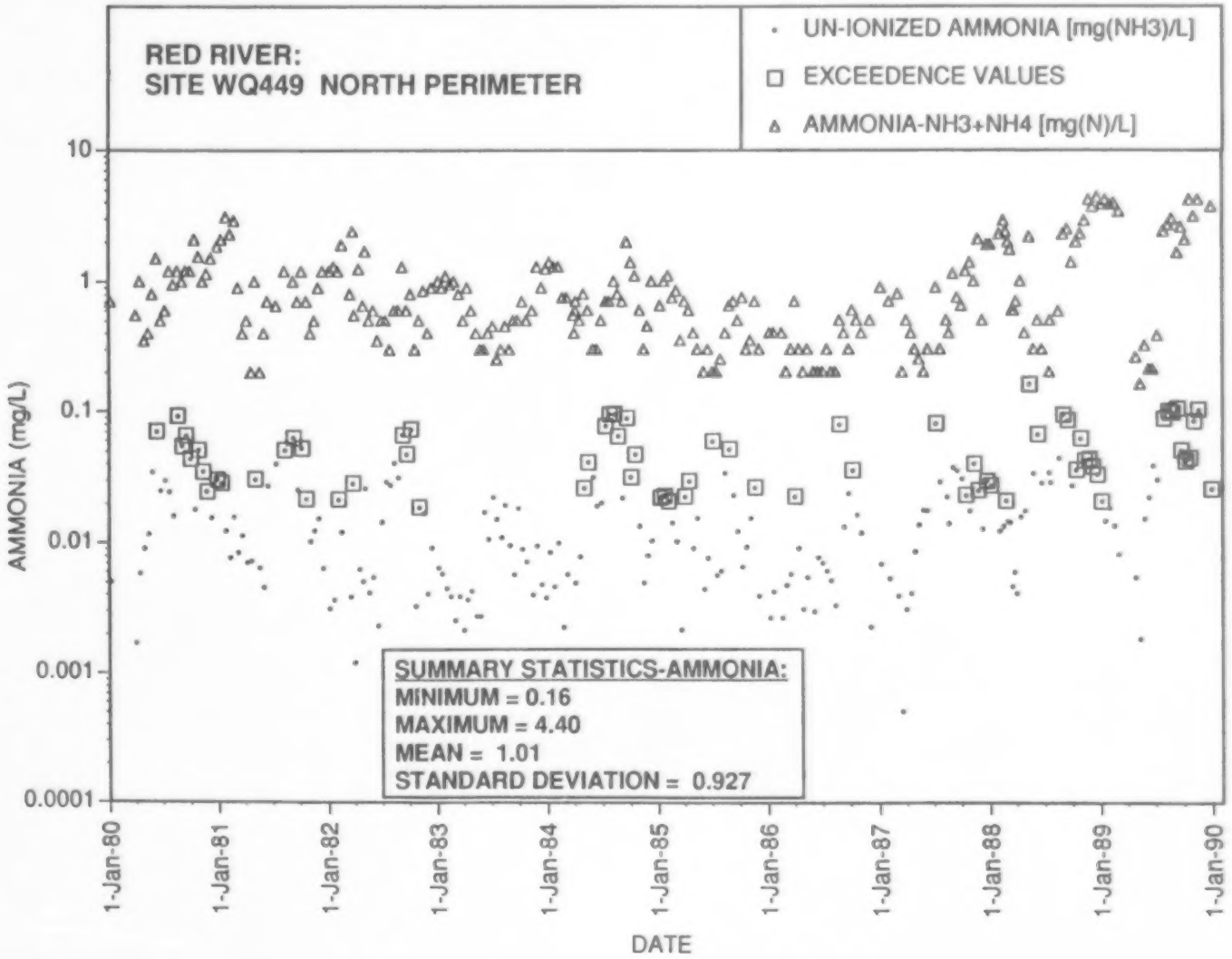


TABLE A39: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERAURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.0239	0.0005	0.1600	0.0250	236	69	29.24%	0.0515
1980	0.0315	0.0017	0.0924	0.0238	21	9	42.86%	0.0518
1981	0.0210	0.0045	0.0625	0.0169	22	6	27.27%	0.0410
1982	0.0192	0.0012	0.0721	0.0194	26	6	23.08%	0.0421
1983	0.0080	0.0021	0.0221	0.0058	26	0	0.00%	
1984	0.0304	0.0022	0.0941	0.0304	24	9	37.50%	0.0620
1985	0.0177	0.0021	0.0583	0.0142	24	8	33.33%	0.0313
1986	0.0122	0.0022	0.0778	0.0169	22	3	13.64%	0.0450
1987	0.0205	0.0005	0.0793	0.0173	23	5	21.74%	0.0391
1988	0.0369	0.0040	0.1600	0.0333	27	12	44.44%	0.0584
1989	0.0435	0.0018	0.1032	0.0356	21	11	52.38%	0.0681
JAN (80-89)	0.0119	0.0026	0.0285	0.0088	18	5	27.78%	0.0240
FEB (80-89)	0.0111	0.0022	0.0213	0.0064	16	3	18.75%	0.0208
MARCH (80-89)	0.0067	0.0005	0.0282	0.0062	22	1	4.55%	0.0282
APRIL (80-89)	0.0094	0.0017	0.0291	0.0072	22	3	13.64%	0.0244
MAY (80-89)	0.0251	0.0018	0.1600	0.0349	19	4	21.05%	0.0642
JUNE (80-89)	0.0204	0.0023	0.0701	0.0190	20	2	10.00%	0.0680
JULY (80-89)	0.0348	0.0050	0.0937	0.0278	21	5	23.81%	0.0788
AUG (80-89)	0.0479	0.0032	0.0990	0.0334	20	9	45.00%	0.0796
SEPT (80-89)	0.0423	0.0056	0.1032	0.0272	21	9	42.86%	0.0687
OCT (80-89)	0.0298	0.0032	0.0721	0.0196	22	13	59.09%	0.0428
NOV (80-89)	0.0266	0.0039	0.1015	0.0258	20	10	50.00%	0.0437
DEC (80-89)	0.0159	0.0022	0.0375	0.0120	15	5	33.33%	0.0310

FIGURE A53: Ammonia and un-ionized ammonia concentrations in the Red River, at site WQ450 at the Lockport Bridge.

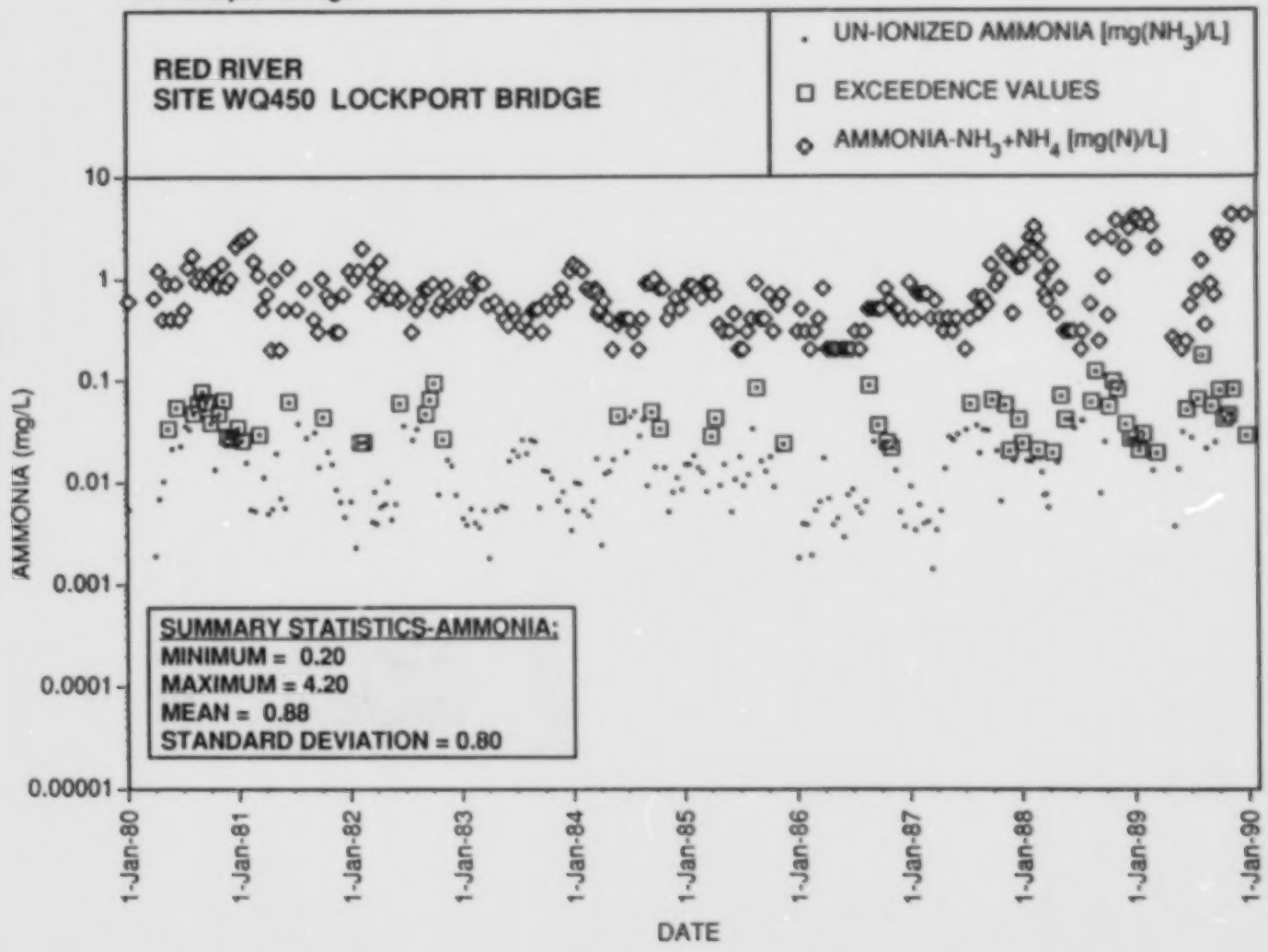


TABLE A40: Summary statistics and exceedence of the un-ionized ammonia objective for aquatic life and wildlife, at site WQ450 at the Lockport Bridge on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: UN-IONIZED AMMONIA (mg/L)
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: CALCULATED (BASED ON TEMPERAURE AND pH)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.0236	0.0014	0.1742	0.0230	240	64	26.67%	0.0494
1980	0.0344	0.0019	0.0770	0.0209	21	12	57.14%	0.0475
1981	0.0185	0.0046	0.0617	0.0152	22	4	18.18%	0.0402
1982	0.0232	0.0023	0.0935	0.0231	25	7	28.00%	0.0487
1983	0.0105	0.0018	0.0264	0.0079	25	0	0.00%	
1984	0.0198	0.0024	0.0492	0.0154	26	3	11.54%	0.0424
1985	0.0182	0.0018	0.0837	0.0164	25	4	16.00%	0.0446
1986	0.0143	0.0019	0.0890	0.0188	23	4	17.39%	0.0430
1987	0.0228	0.0014	0.0634	0.0183	25	5	20.00%	0.0479
1988	0.0354	0.0056	0.1211	0.0289	27	12	44.44%	0.0543
1989	0.0416	0.0037	0.1742	0.0370	21	13	61.90%	0.0553
JAN (80-89)	0.0134	0.0023	0.0297	0.0091	17	5	29.41%	0.0254
FEB (80-89)	0.0114	0.0019	0.0250	0.0078	19	3	15.79%	0.0234
MARCH (80-89)	0.0090	0.0014	0.0295	0.0066	24	2	8.33%	0.0245
APRIL (80-89)	0.0112	0.0019	0.0423	0.0099	20	3	15.00%	0.0301
MAY (80-89)	0.0202	0.0037	0.0696	0.0173	19	4	21.05%	0.0473
JUNE (80-89)	0.0277	0.0029	0.0617	0.0190	20	4	20.00%	0.0567
JULY (80-89)	0.0296	0.0050	0.0650	0.0172	20	2	10.00%	0.0614
AUG (80-89)	0.0497	0.0065	0.1742	0.0404	20	7	35.00%	0.0907
SEPT (80-89)	0.0335	0.0056	0.0770	0.0214	21	8	38.10%	0.0567
OCT (80-89)	0.0329	0.0065	0.0961	0.0270	22	10	45.45%	0.0553
NOV (80-89)	0.0283	0.0051	0.0809	0.0240	20	10	50.00%	0.0449
DEC (80-89)	0.0151	0.0018	0.0410	0.0134	18	6	33.33%	0.0324

FIGURE A54: Ammonia and un-ionized ammonia levels in the Red River, at site WQ142 at the Selkirk Bridge.

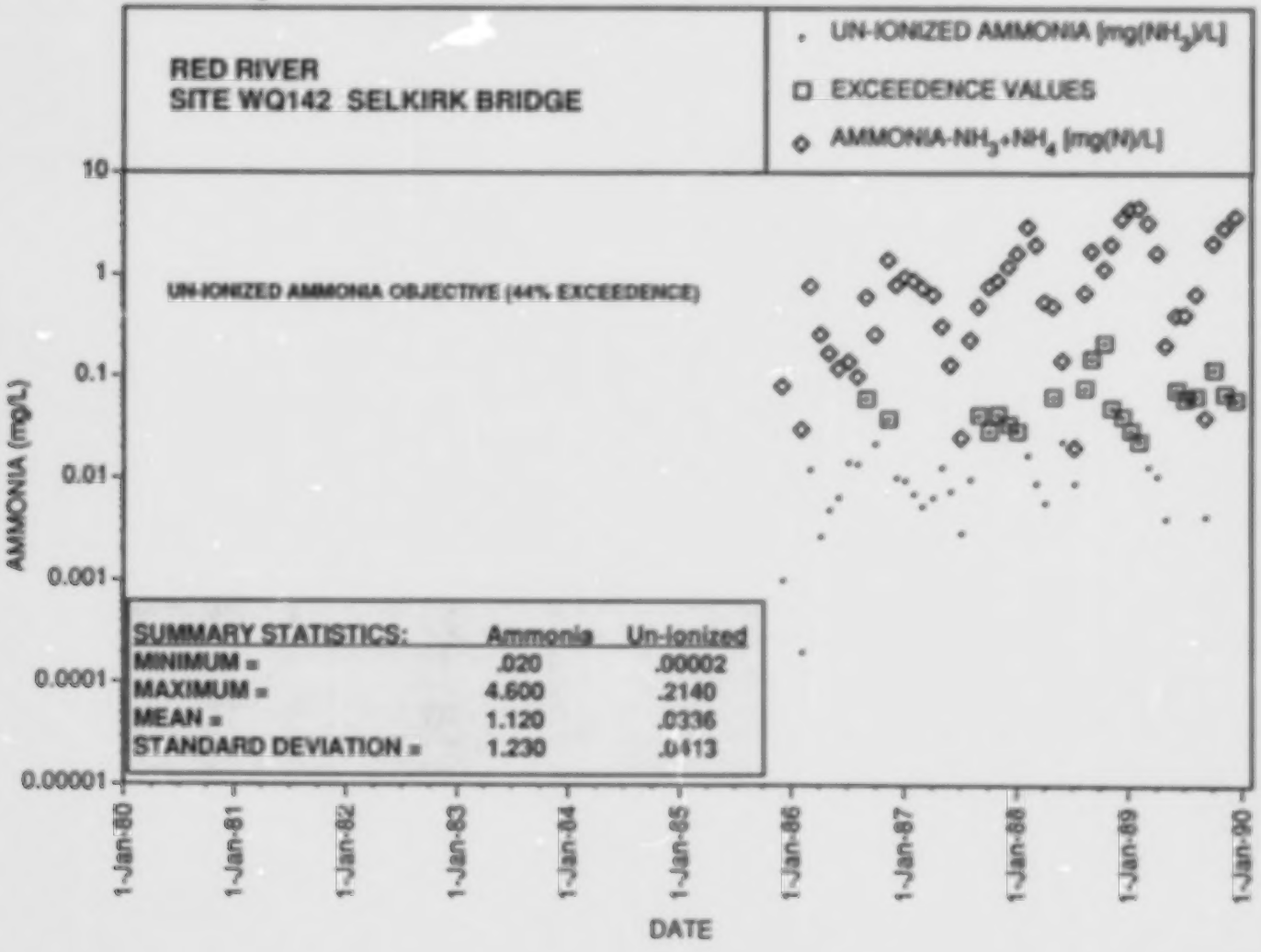


TABLE A41: Trend analysis and paired t-test results on ammonia data.

TREND ANALYSIS RESULTS: AMMONIA. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.02	0.240	N/S	INCREASING	86
WQ451 HEADINGLEY	0.03	0.012	*	DECREASING	233
WQ452 WEST PERIMETER	~	~	~	~	~
WQ453 MAIN STREET BRIDGE	0.00	0.490	N/S	DECREASING	226
RED RIVER SITES:					
WQ367 SOUTH GATE OF FLOODWAY	0.01	0.456	N/S	DECREASING	48
WQ445 FLOODWAY CONTROL	0.08	0.000	**	DECREASING	243
WQ576 FORT GARY BRIDGE	0.06	0.001	**	INCREASING	179
WQ447 NORWOOD BRIDGE	~	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~	~
WQ449 NORTH PERIMETER	0.08	0.000	**	INCREASING	240
WQ450 LOCKPORT BRIDGE	0.05	0.000	**	INCREASING	243
WQ142 SELKIRK	0.09	0.004	**	INCREASING	91

PAIRED T-TEST RESULTS: AMMONIA DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1986-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.000	**	-0.929	39
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.000	**	-0.917	46
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.743	N/S	-0.010	39

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)
~ indicates insufficient data to perform analysis

FIGURE A55: Total Kjeldhal nitrogen concentrations in the Assiniboine River, at site WQ018 at Headingley.

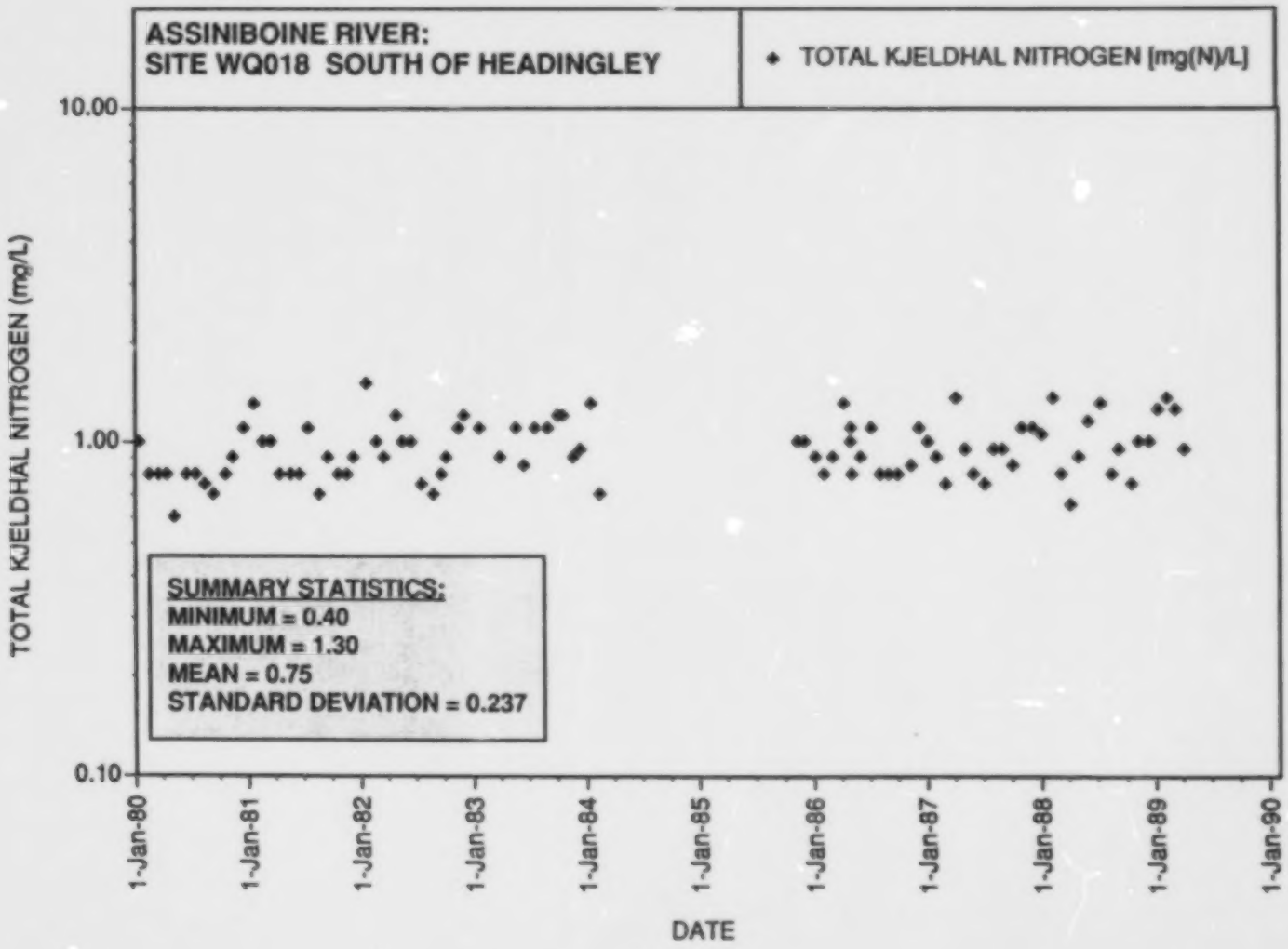


FIGURE A56: Total Kjeldhal nitrogen concentrations in the Assiniboine River, at site WQ451 at Headingley.

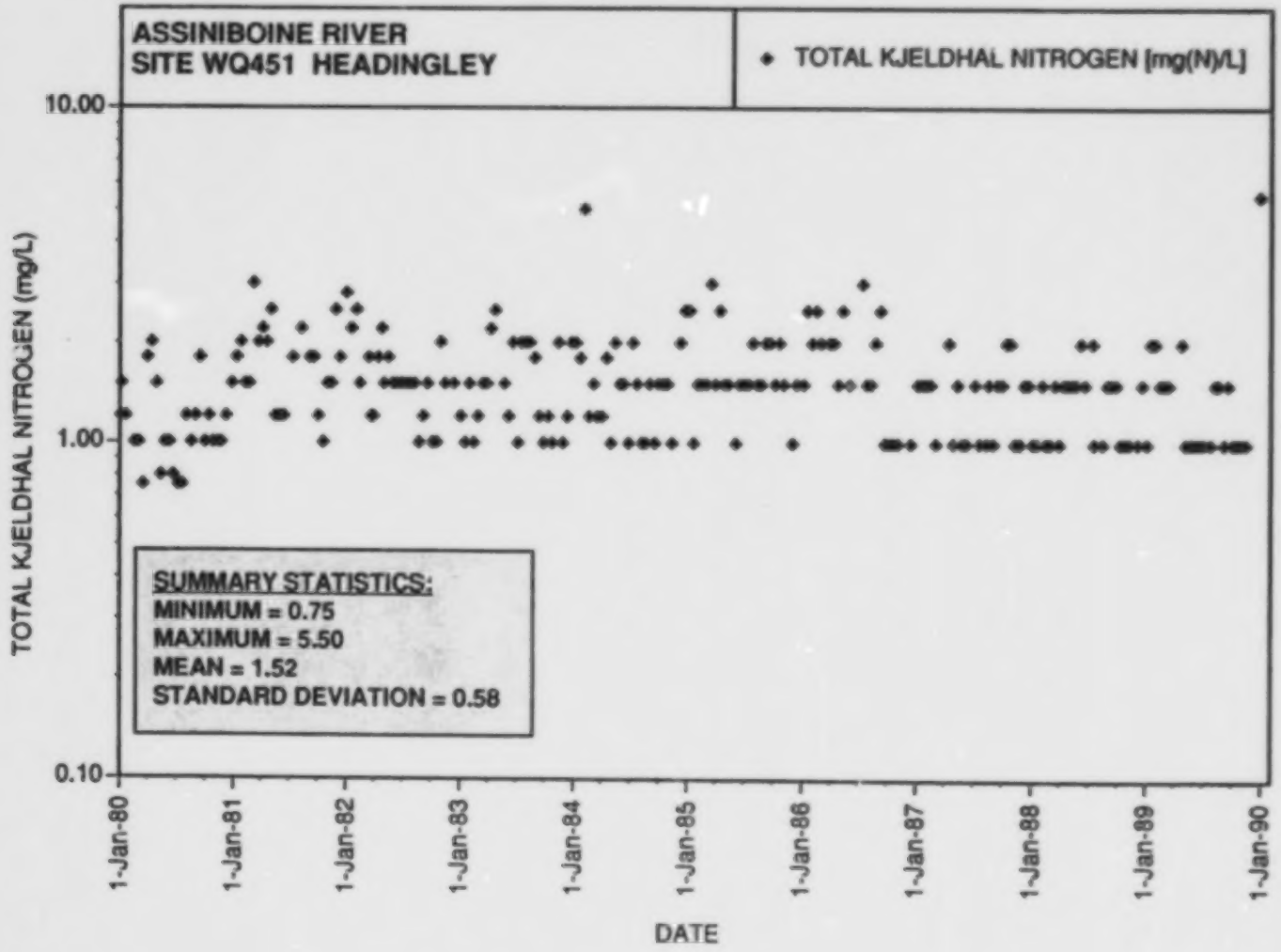


FIGURE A57: Total Kjeldhal nitrogen concentrations in the Assiniboine River, at site WQ453 at the Main Street Bridge.

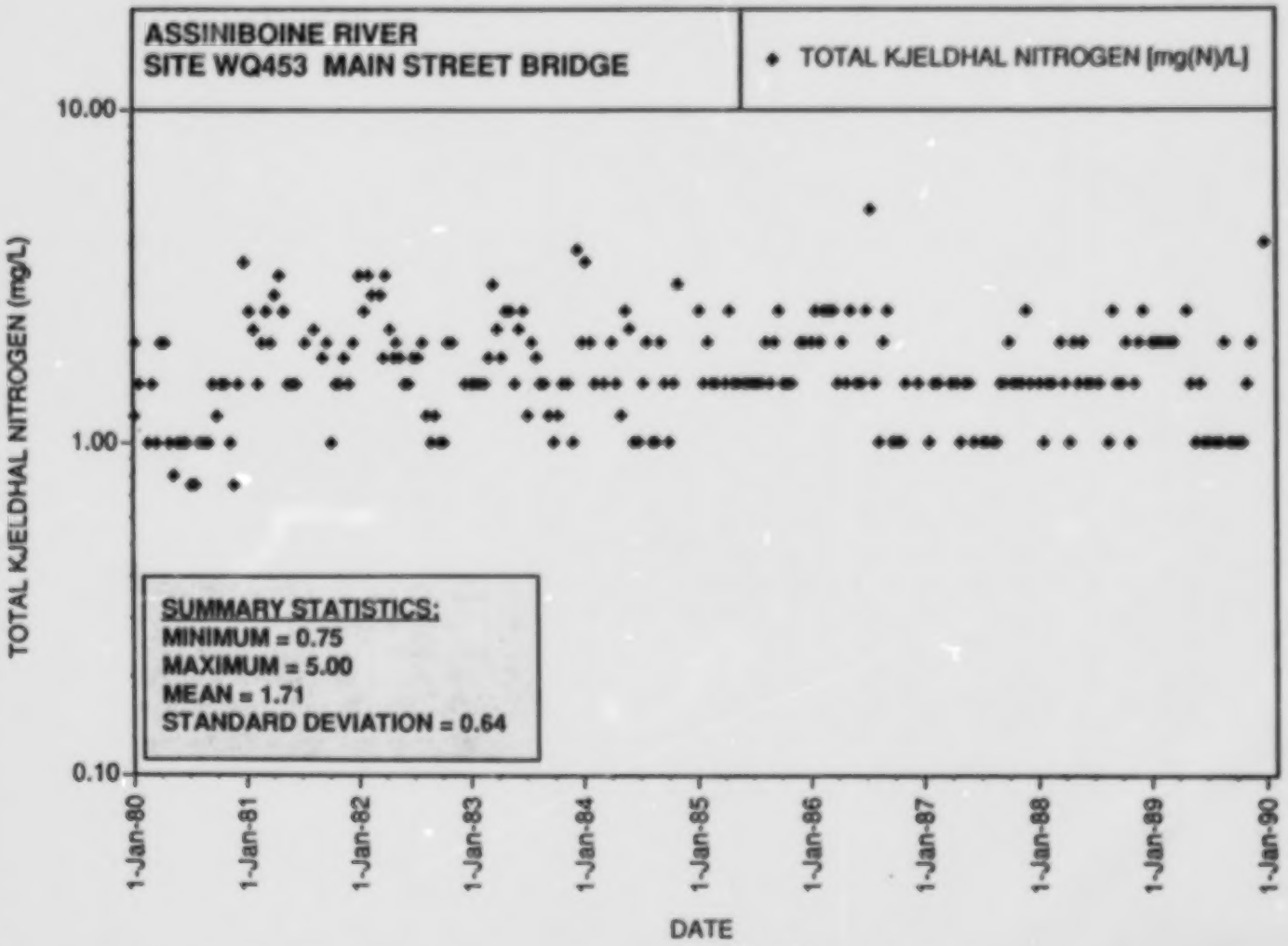


FIGURE A58: Total kjeldhal nitrogen concentrations in the Red River, at site WQ367 at the south gate of the floodway.

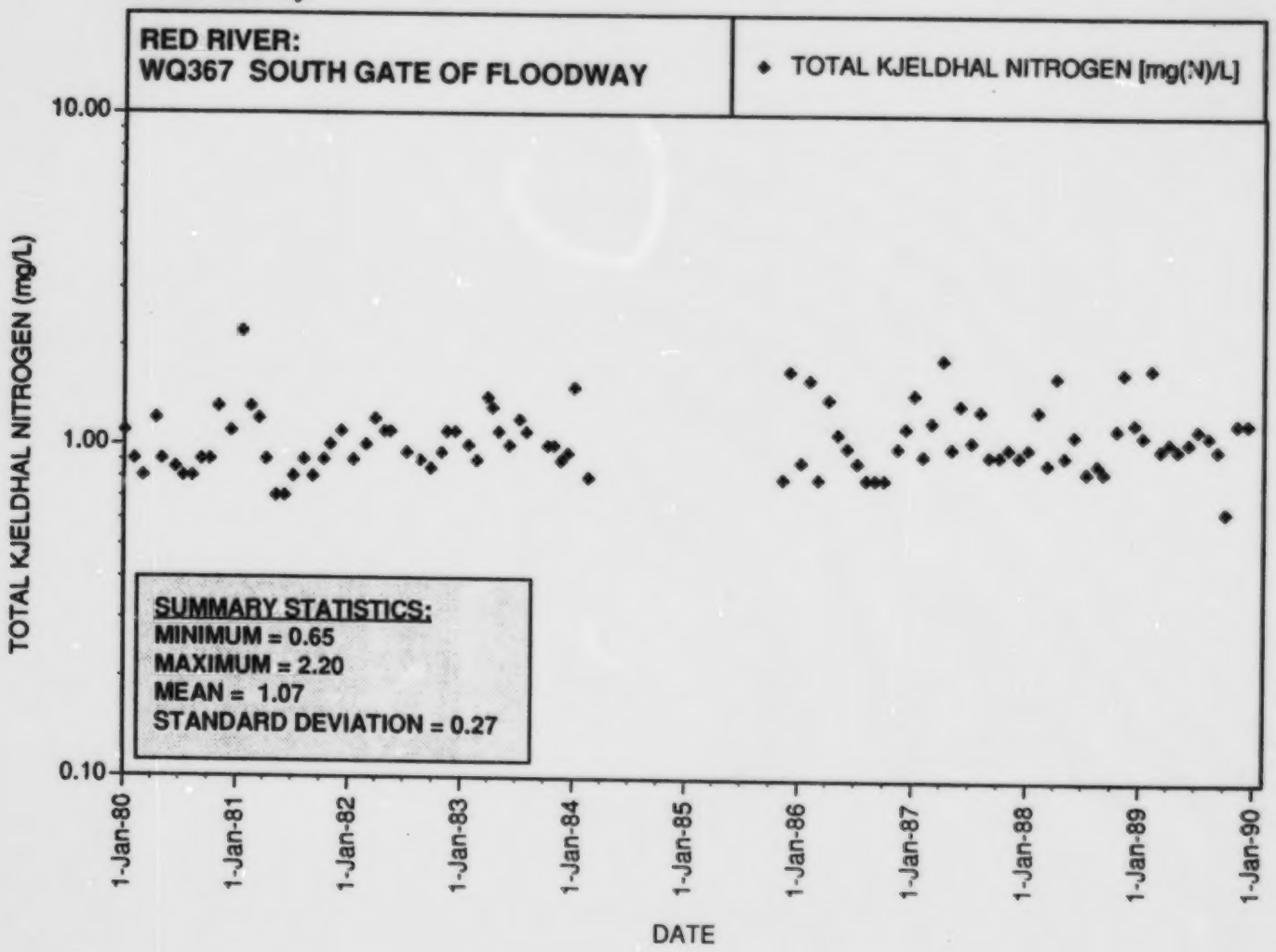


FIGURE A59: Total kjeldhal nitrogen concentrations in the Red River, at site WQ445 at the south Floodway control.

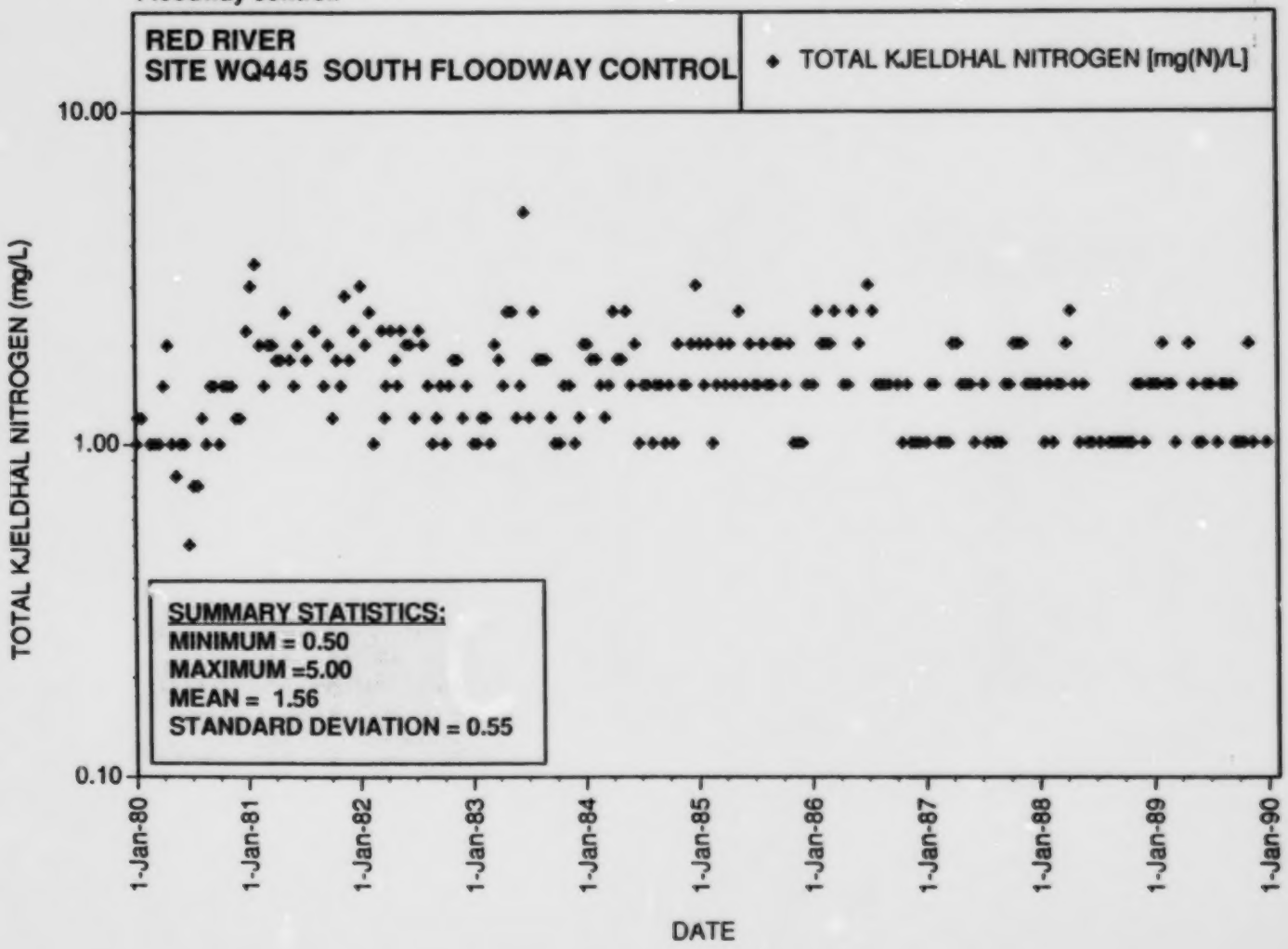


FIGURE A60 Total kjeldhal nitrogen concentrations in the Red River, at site WQ576 at the Fort Gary Bridge.

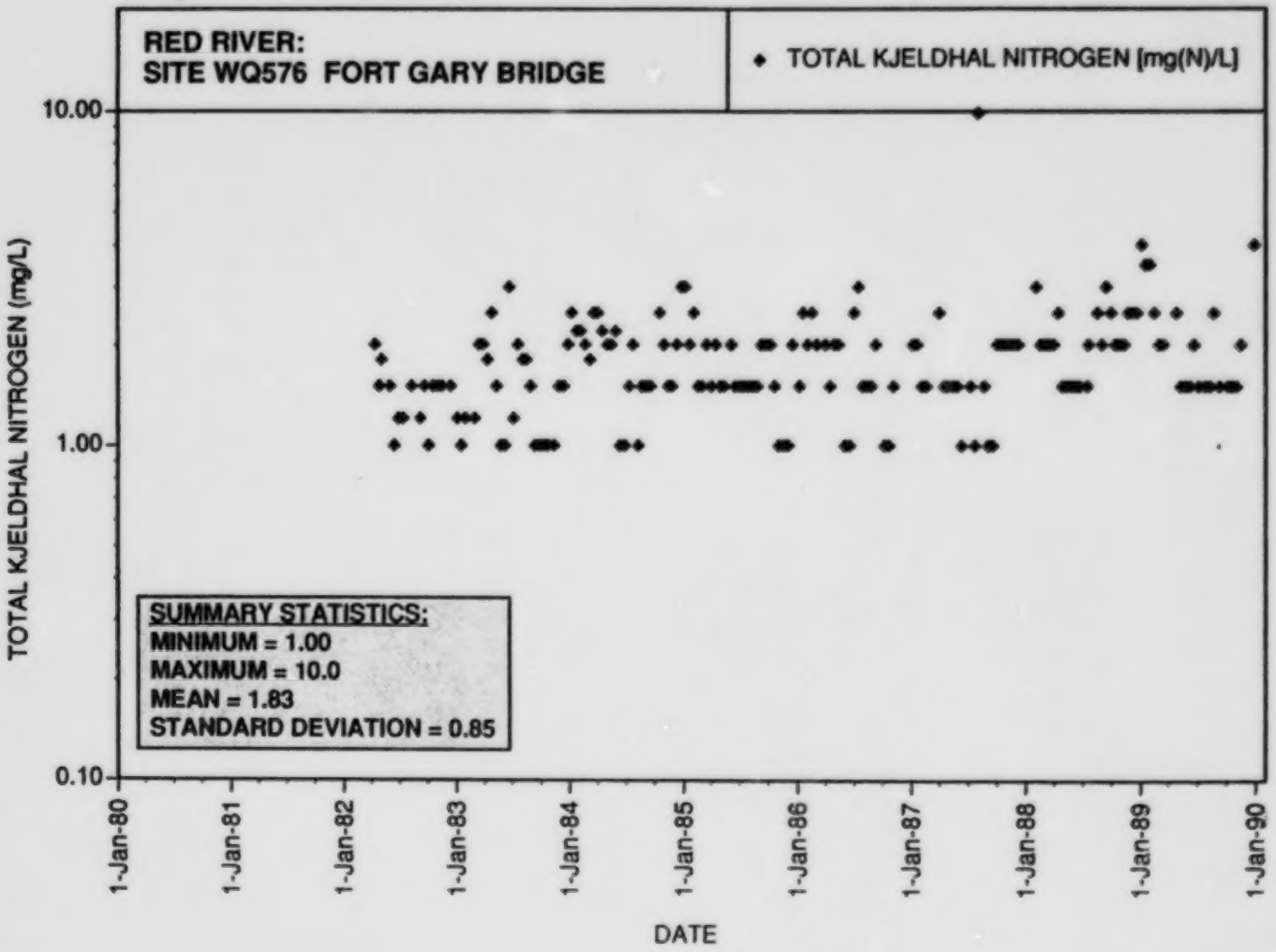


FIGURE A61: Total kjeldhal nitrogen concentrations in the Red River, at site WQ449 at the north perimeter.

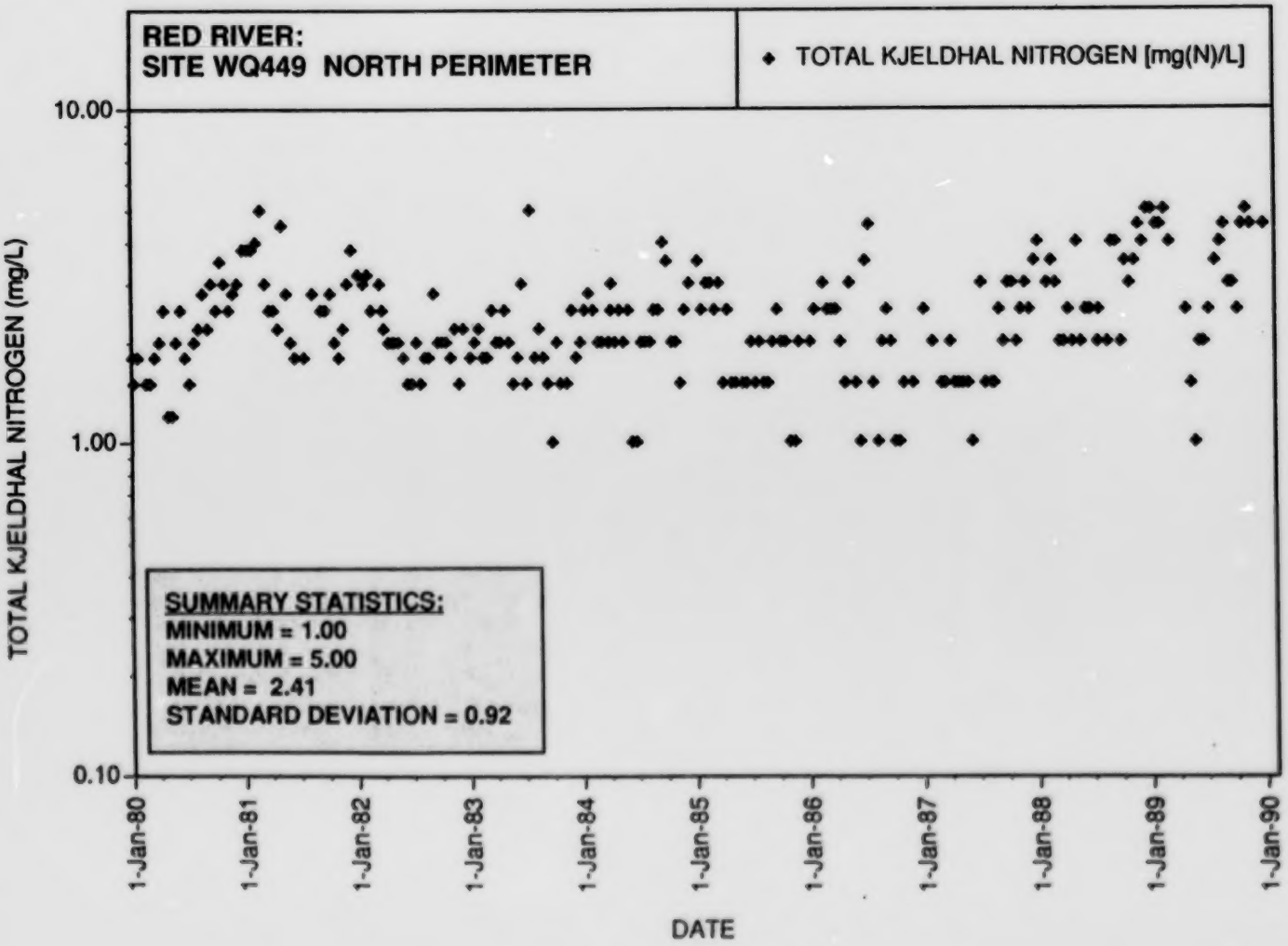


FIGURE A62: Total kjeldhal nitrogen concentrations in the Red River, at site WQ450 at Lockport.

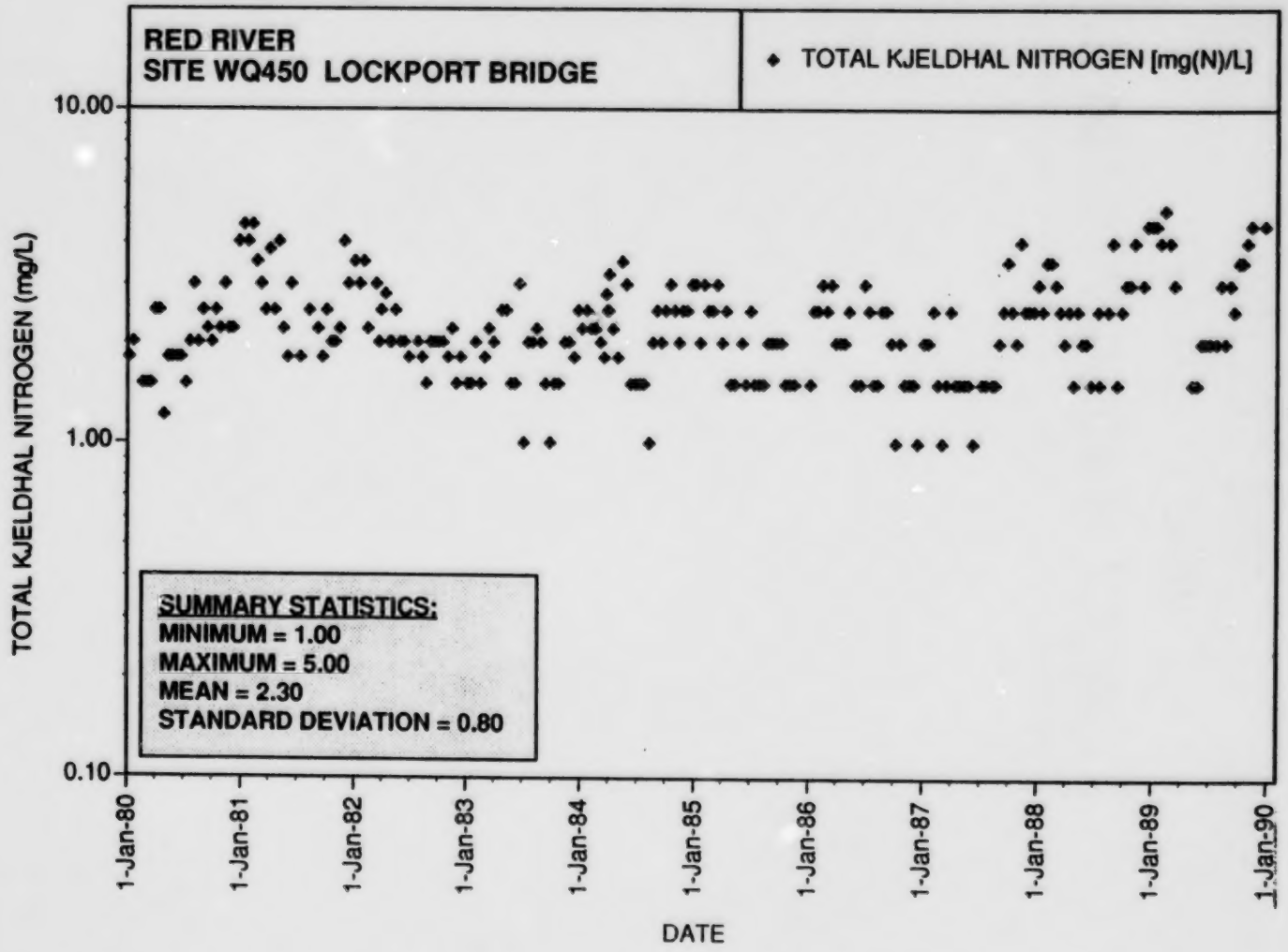


FIGURE A63: Total kjeldhal nitrogen concentrations in the Red River, at site WQ142 at Selkirk.

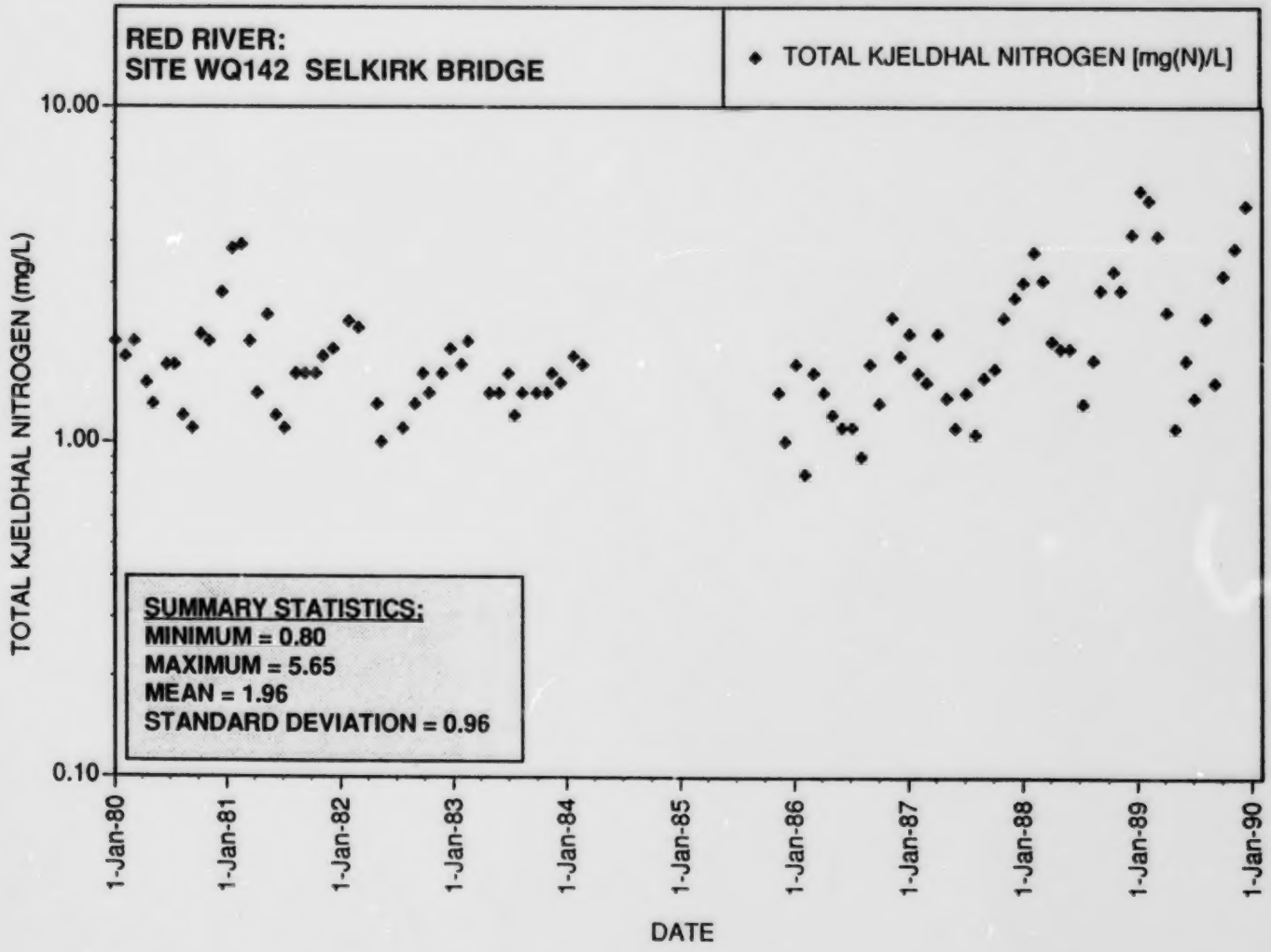


TABLE A42: Trend analysis and paired t-test results on total kjeldhal nitrogen data.

TREND ANALYSIS RESULTS: TOTAL KJELDHAL NITROGEN. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.06	0.005 **	INCREASING	133
WQ451 HEADINGLEY	0.01	0.259 N/S	INCREASING	281
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	0.00	0.588 N/S	INCREASING	276
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.02	0.177 N/S	INCREASING	123
WQ445 FLOODWAY CONTROL	0.00	0.576 N/S	DECREASING	293
WQ576 FORT GARY BRIDGE	0.06	0.002 **	INCREASING	177
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	0.07	0.000 **	INCREASING	287
WQ450 LOCKPORT BRIDGE	0.04	0.001 **	INCREASING	294
WQ142 SELKIRK	0.13	0.000 **	INCREASING	158

PAIRED T-TEST RESULTS: TOTAL KJELDHAL NITROGEN DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.000 **	-0.970	76
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.000 **	-0.881	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.000 **	-0.122	78

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A64: Nitrate and nitrite concentrations in the Assiniboine River, at site WQ018 at Headingley.

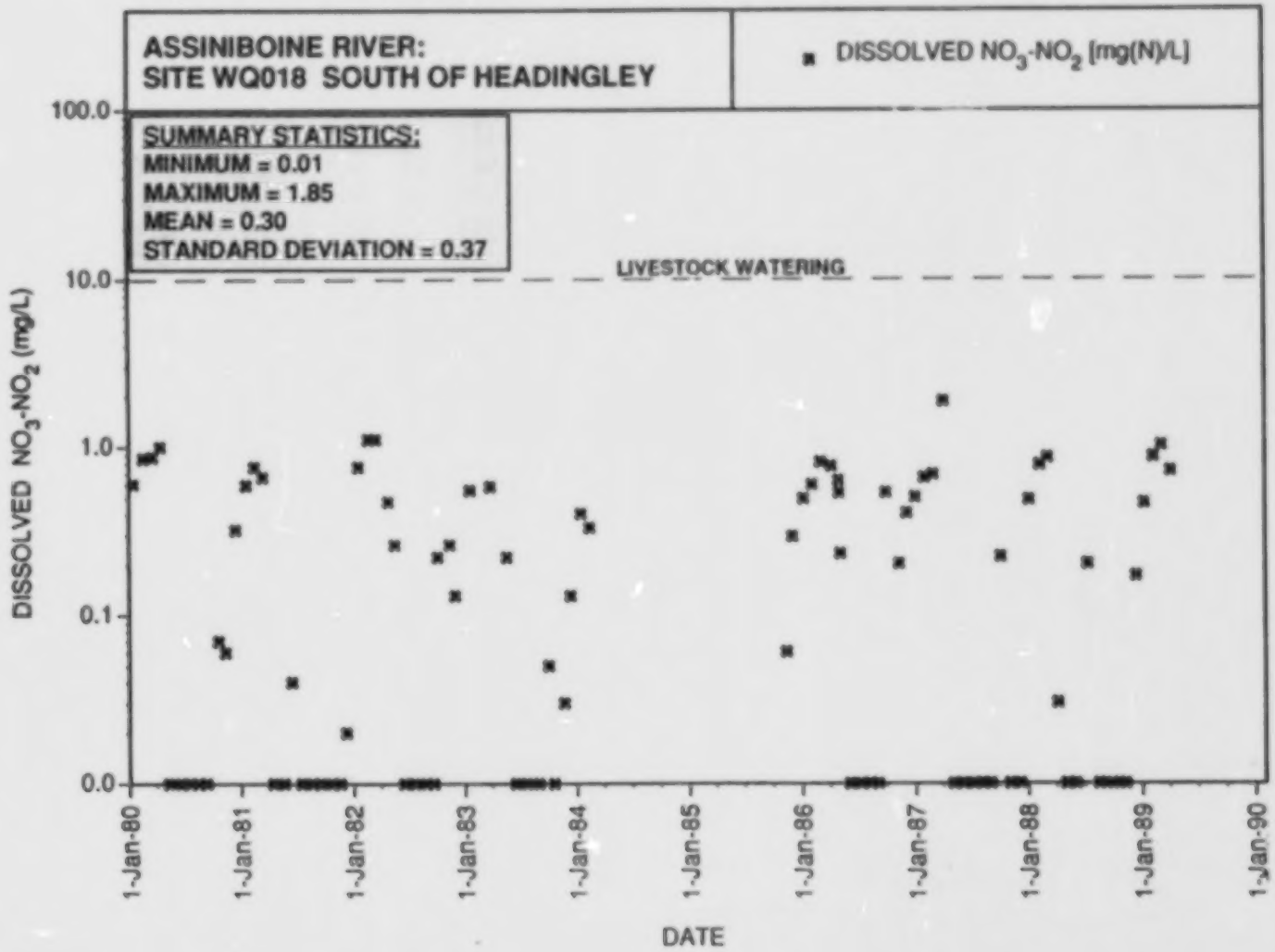


FIGURE A65: Nitrate and nitrite concentrations in the Assiniboine River, at site WQ451 at Headingley.

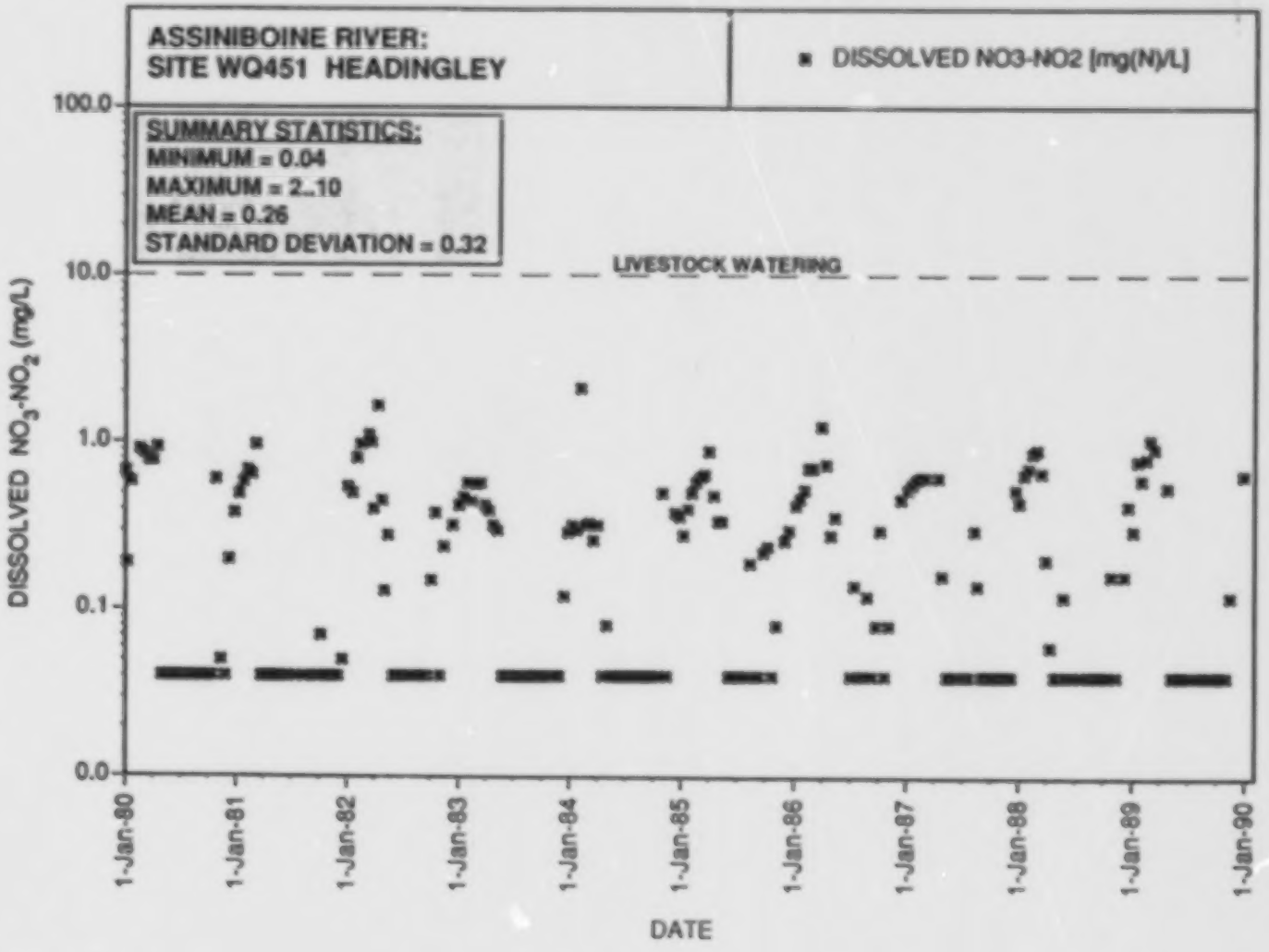


FIGURE A66: Nitrate and nitrite concentrations in the Assiniboine River, at site WQ453 at the west perimeter.

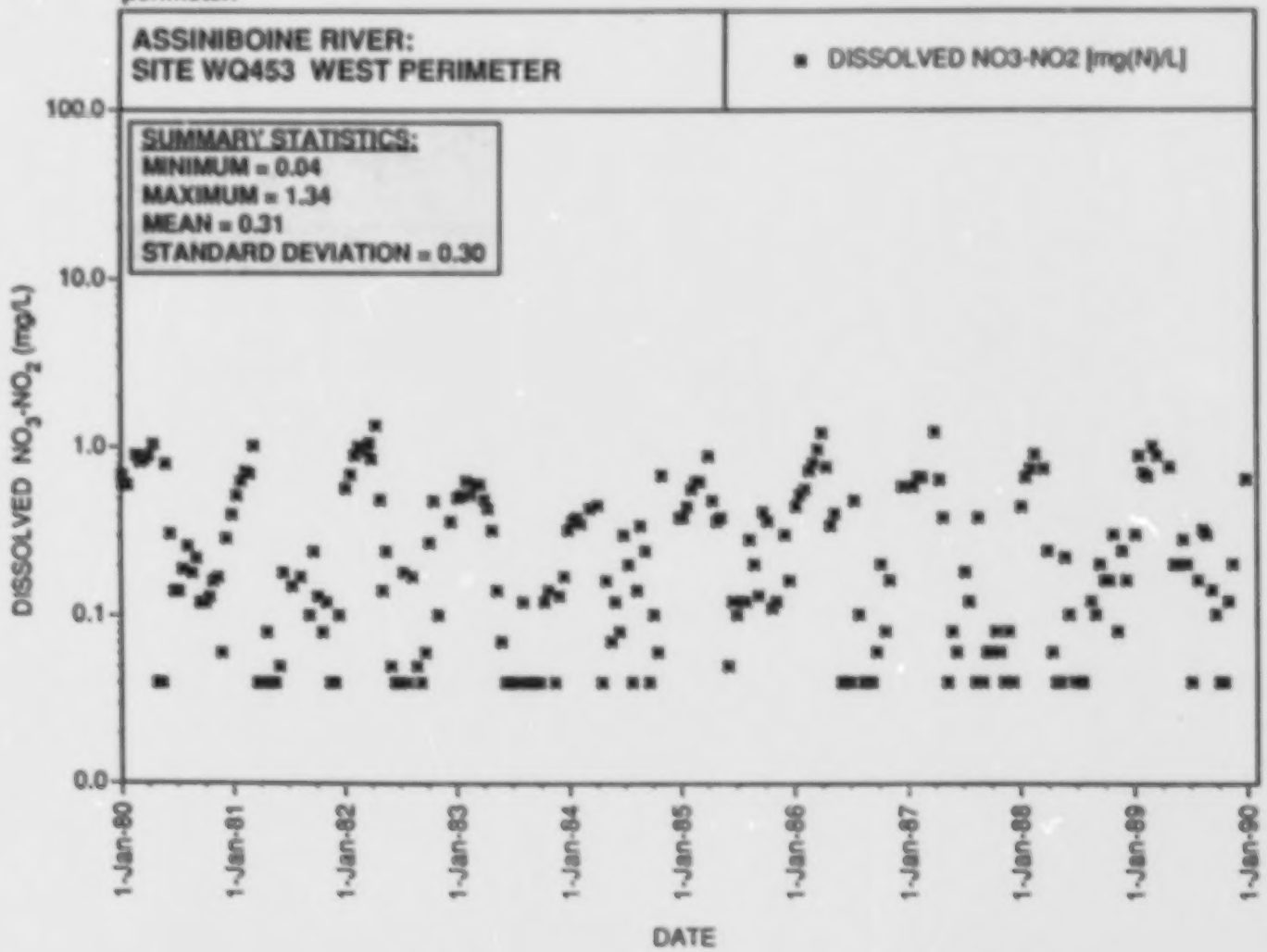


FIGURE A67: Nitrate and nitrite concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

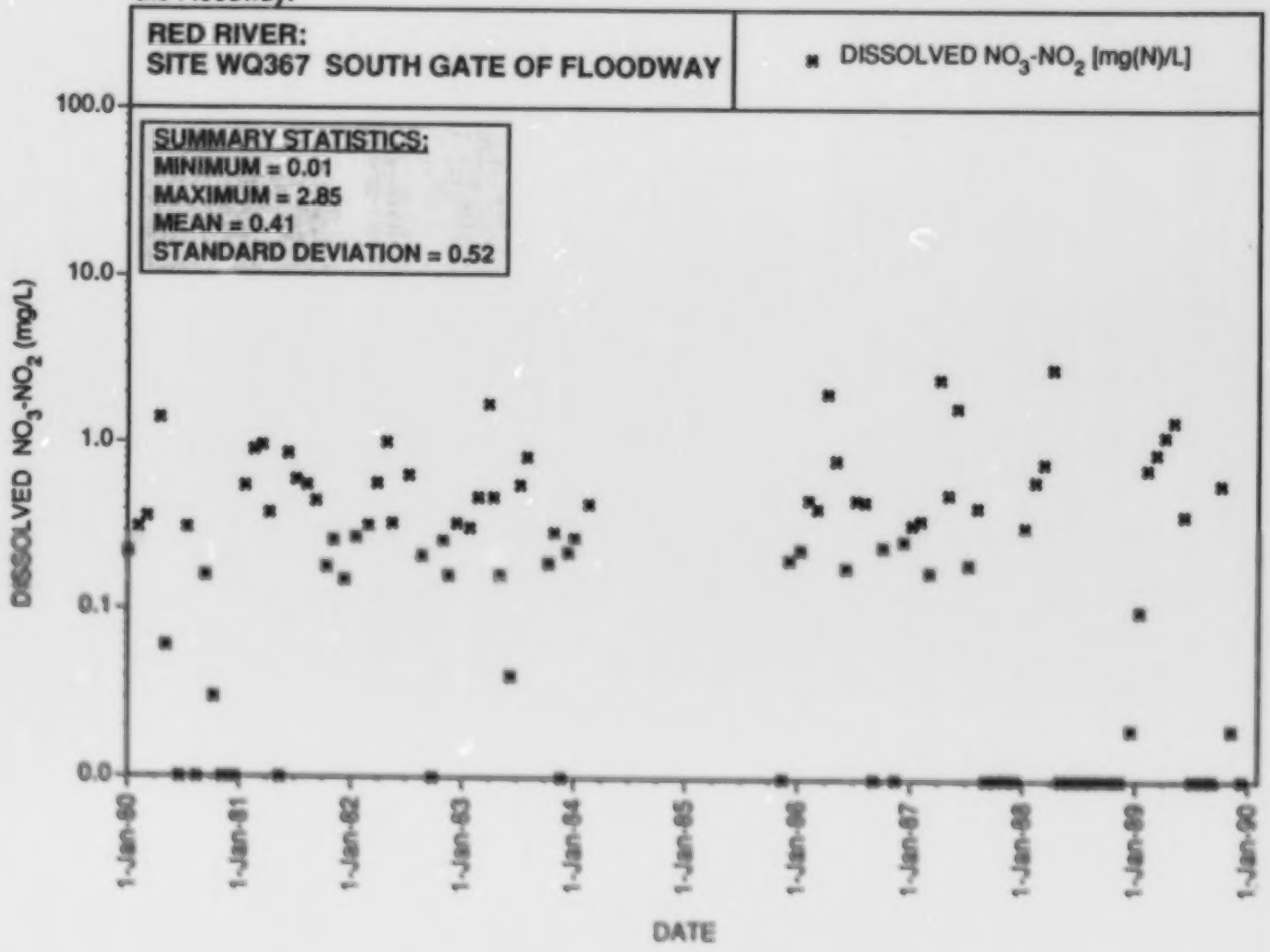


FIGURE A68: Nitrate and nitrite concentrations in the Red River, at site WQ445 at the south Floodway control.

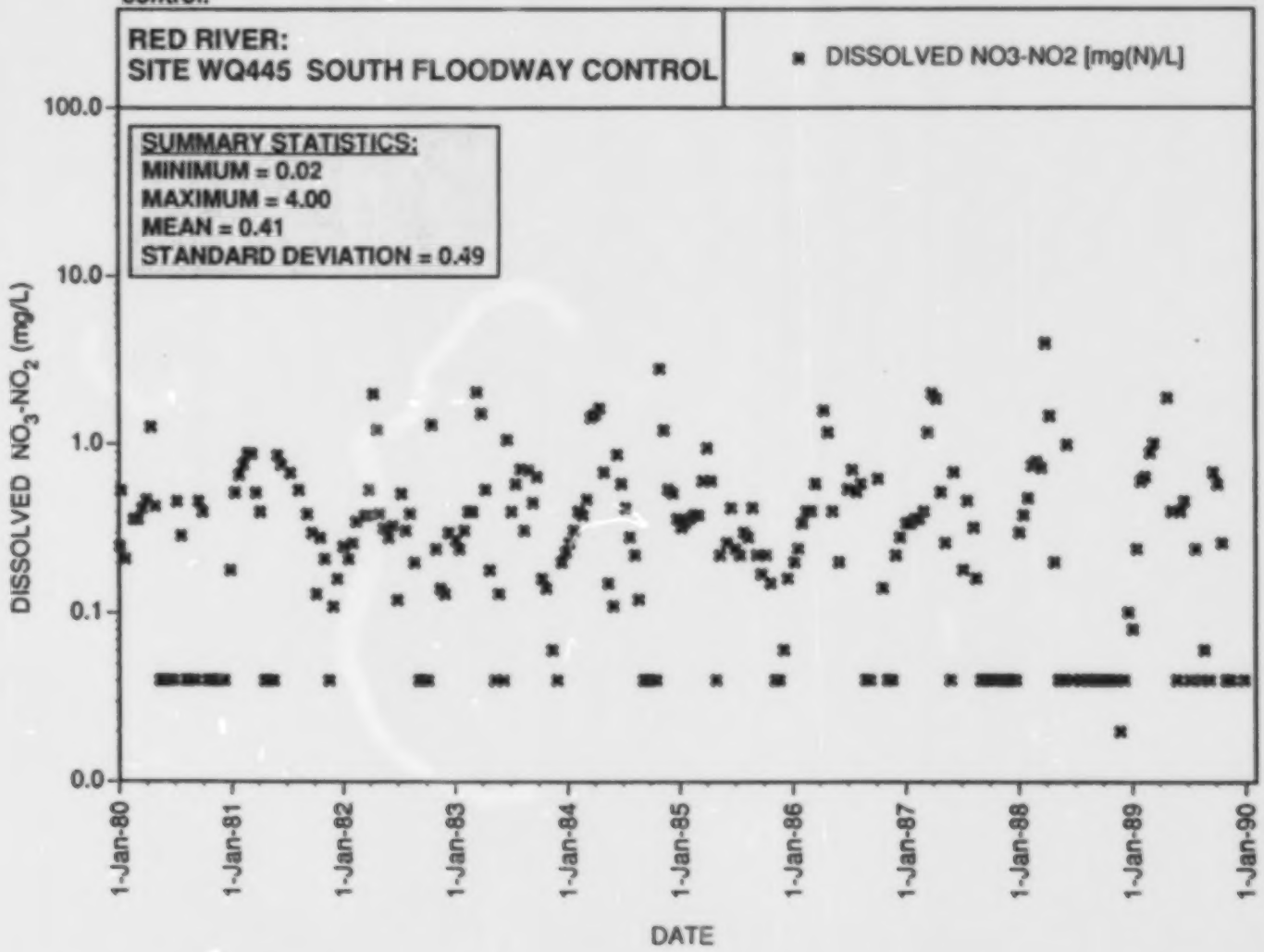


FIGURE A69: Nitrate and nitrite concentrations in the Red River, at site WQ576 at the Fort Gary Bridge.

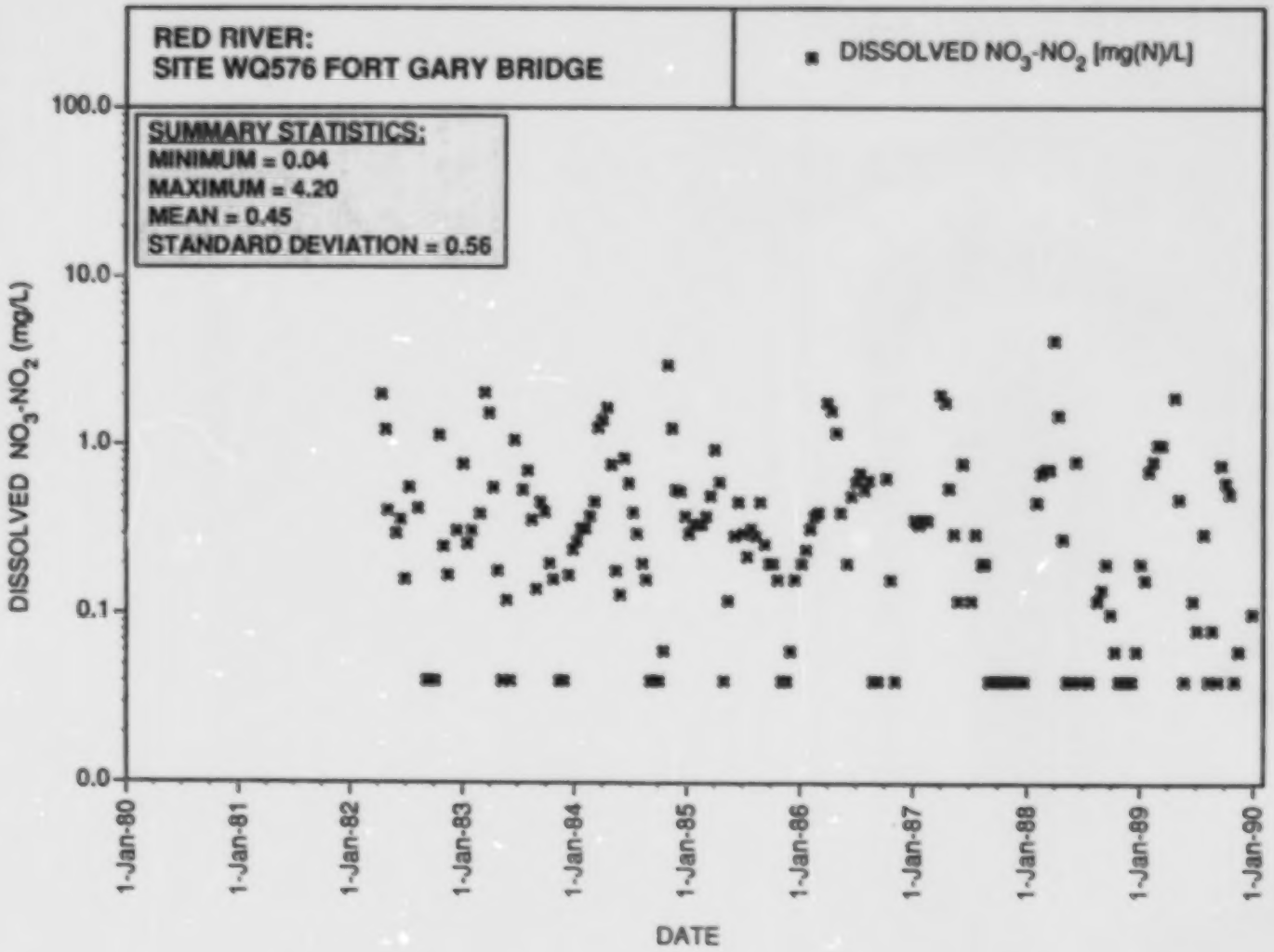


FIGURE A70: Nitrate and nitrite concentrations in the Red River, at site WQ449 at the north perimeter.

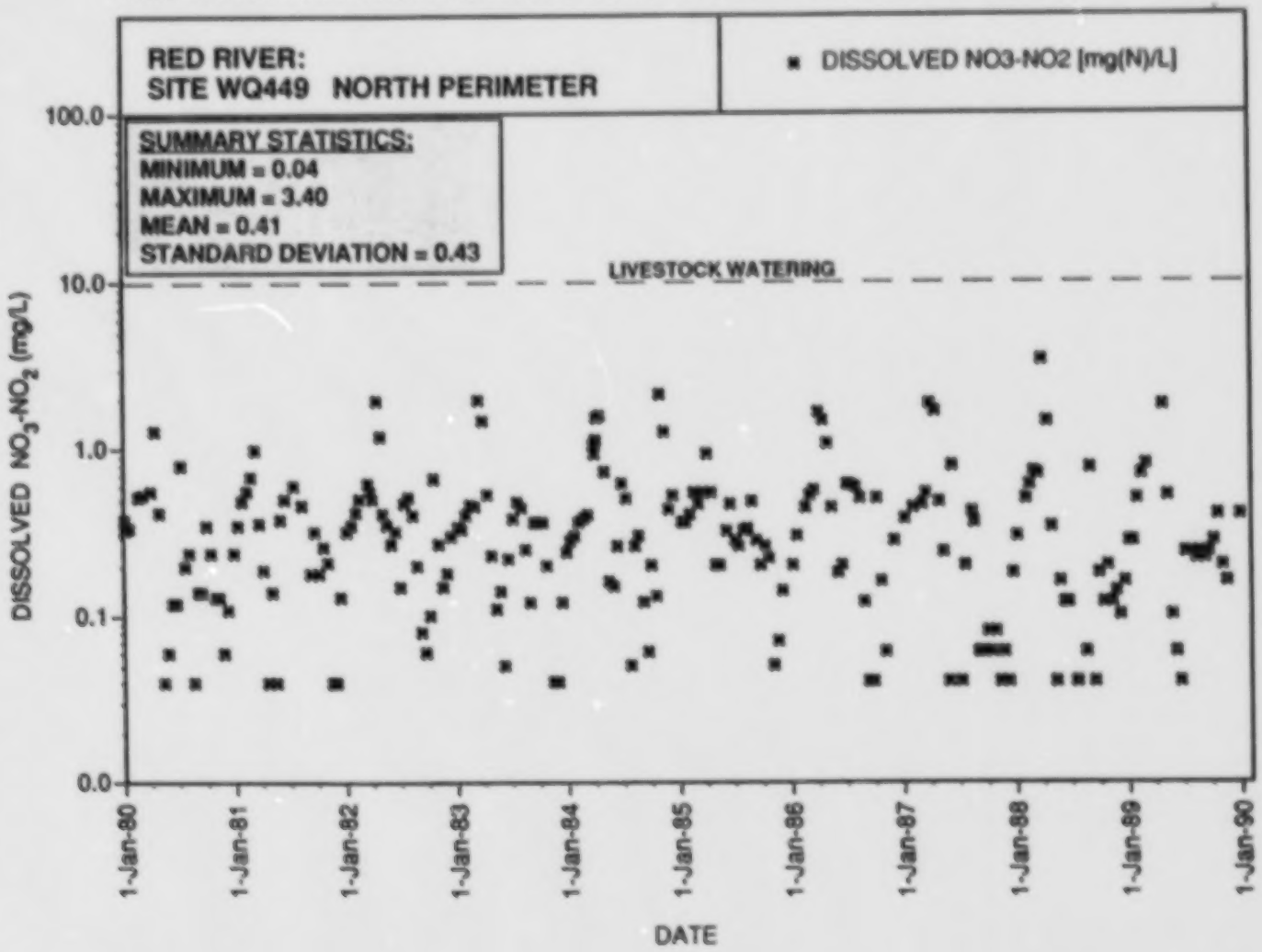


FIGURE A71: Nitrate and nitrite concentrations in the Red River, at site WQ450 at Lockport.

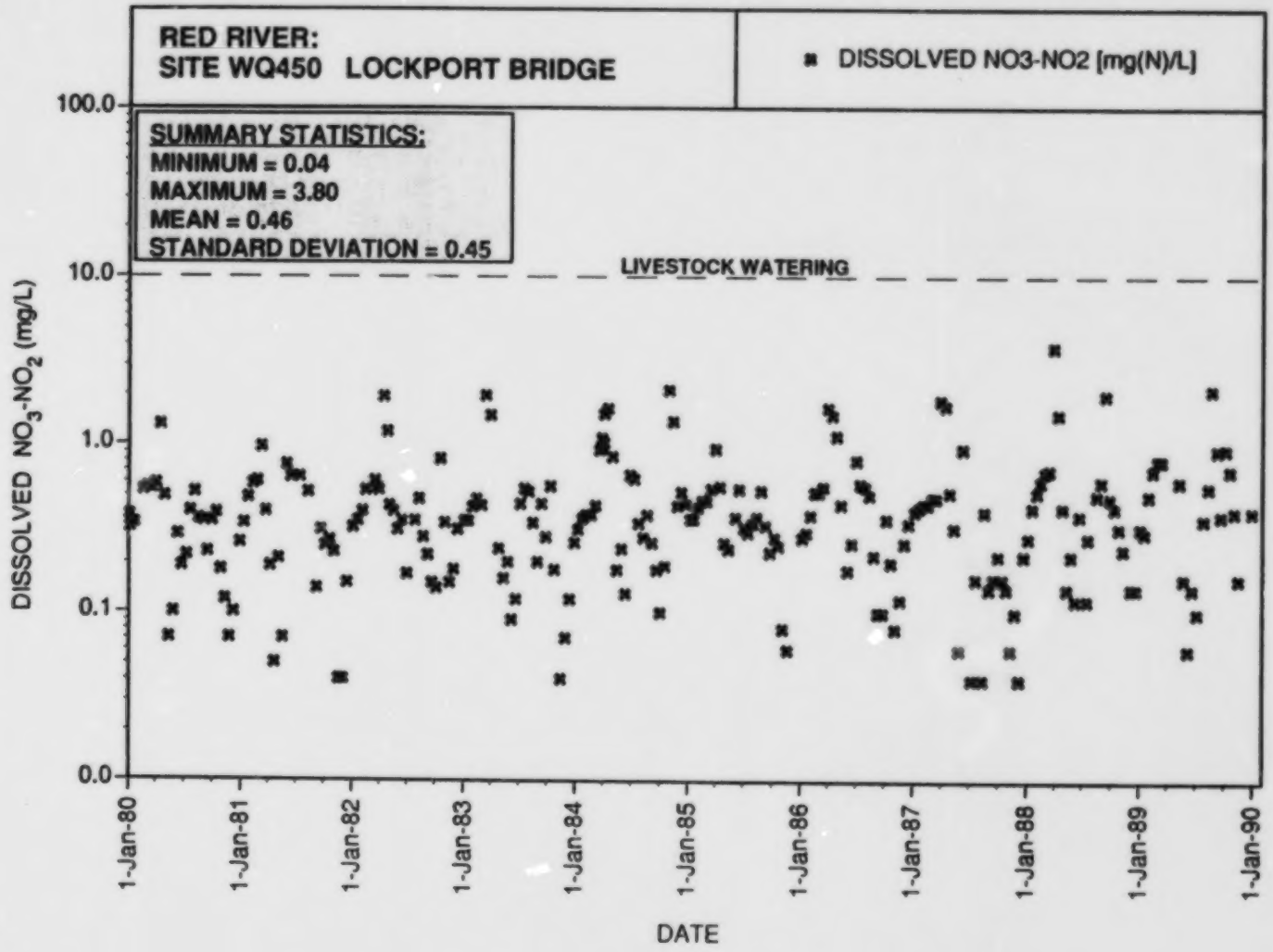


FIGURE A72: Nitrate and nitrite concentrations in the Red River, at site WQ142 at Selkirk.

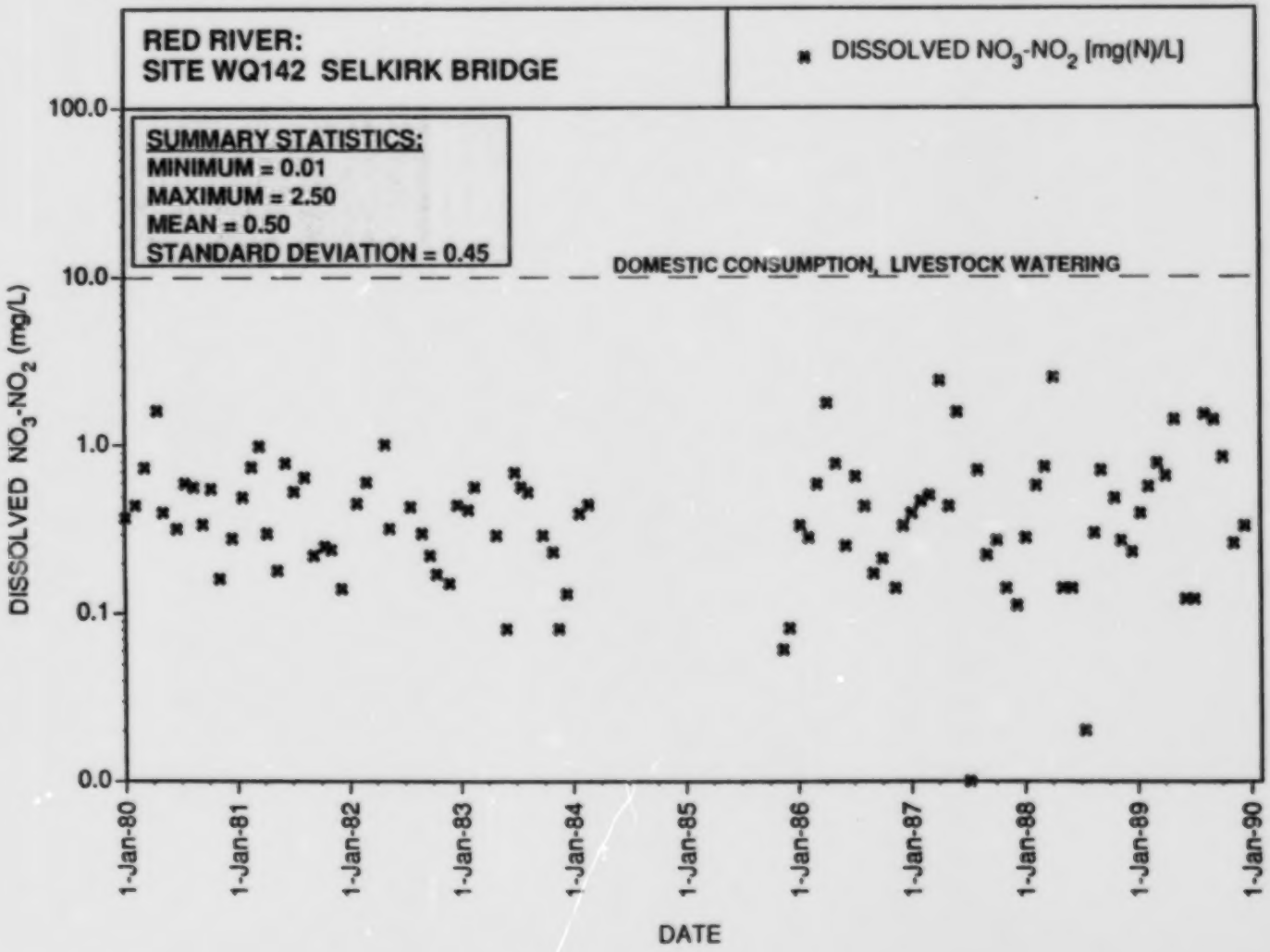


TABLE A43: Trend analysis and paired t-test results on nitrate/nitrite data.

TREND ANALYSIS RESULTS: NITRATE/NITRITE. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.00	0.955 N/S	INCREASING	174
WQ451 HEADINGLEY	0.01	0.107 N/S	INCREASING	283
WQ452 WEST PERIMETER	~	~ ~	~	~
WQ453 MAIN STREET BRIDGE	0.03	0.008 **	DECREASING	277
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.00	0.524 N/S	DECREASING	123
WQ445 FLOODWAY CONTROL	0.00	0.735 N/S	DECREASING	292
WQ576 FORT GARY BRIDGE	0.01	0.272 N/S	DECREASING	178
WQ447 NORWOOD BRIDGE	~	~ ~	~	~
WQ448 REDWOOD BRIDGE	~	~ ~	~	~
WQ449 NORTH PERIMETER	0.00	0.443 N/S	DECREASING	285
WQ450 LOCKPORT BRIDGE	0.00	0.382 N/S	INCREASING	294
WQ142 SELKIRK	0.00	0.825 N/S	DECREASING	202

PAIRED T-TEST RESULTS: NITRATE/NITRITE DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.000 **	-0.192	76
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.001 **	-0.102	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.030 *	-0.124	78

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)
~ indicates insufficient data to perform analysis

TABLE A73: Phosphorus concentrations in the Assiniboine River, at site WQ018 at Headingley.

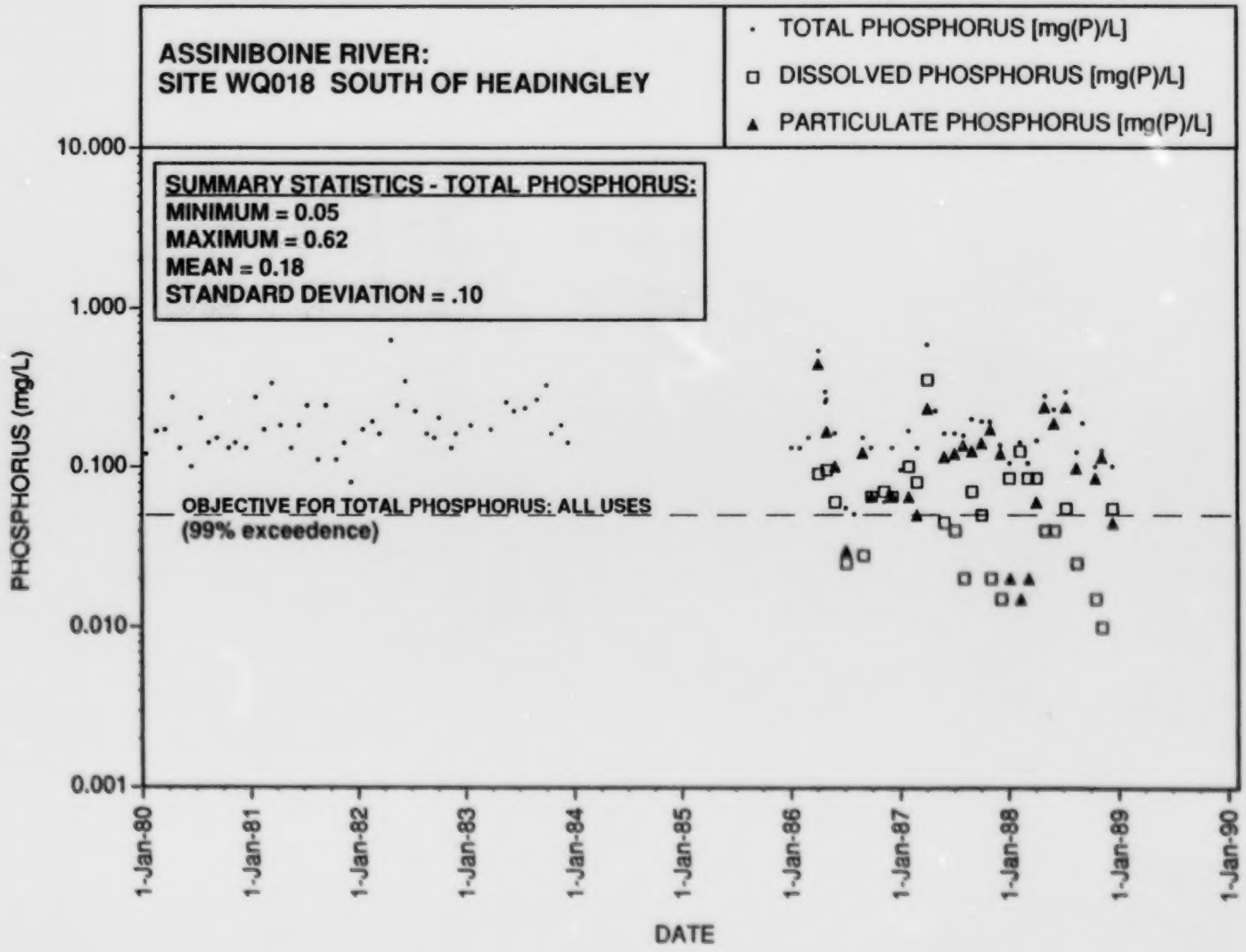


TABLE A74: Phosphorus concentrations in the Assiniboine River, at site WQ451 at Headingley.

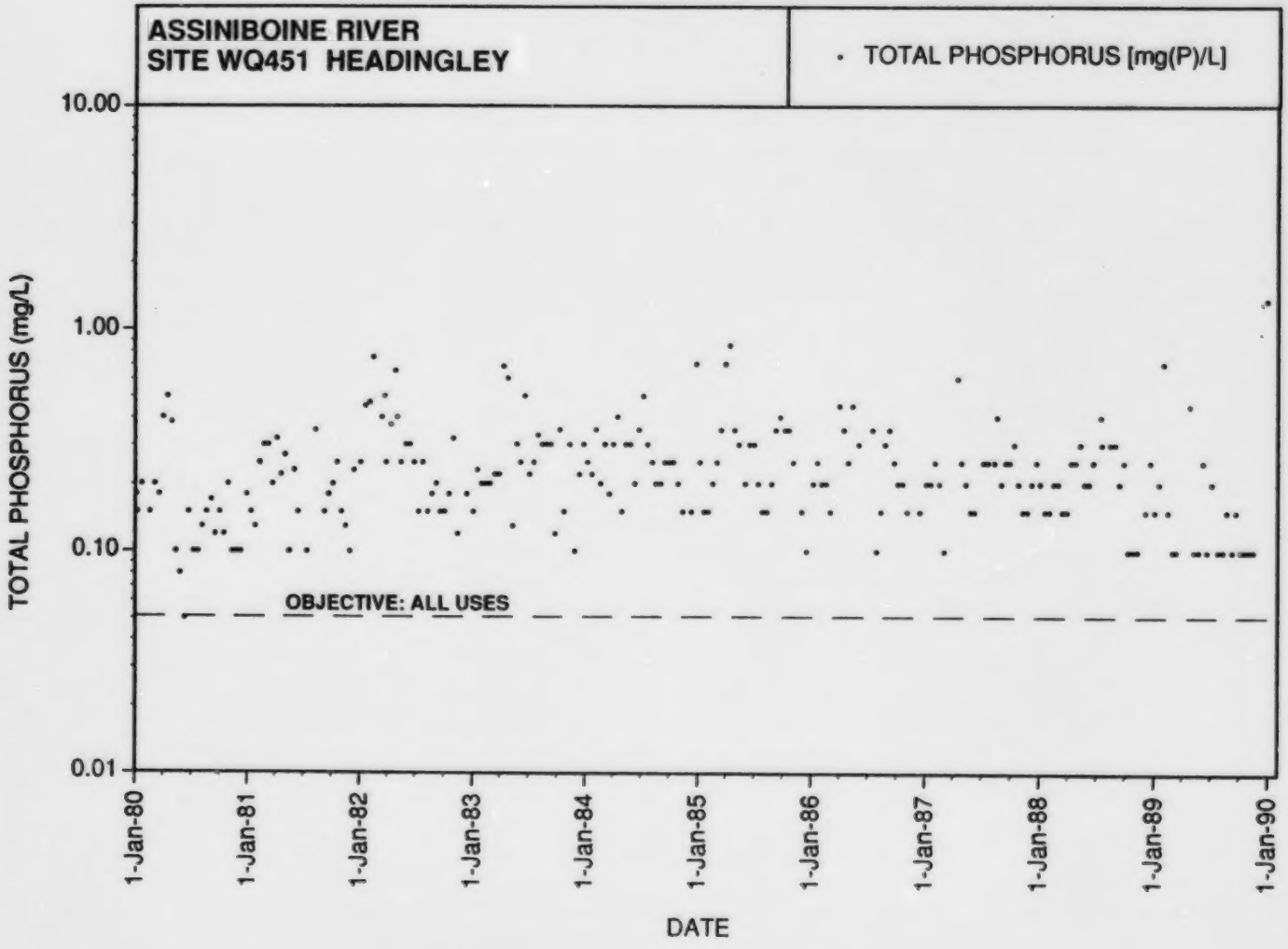


TABLE A44: Summary statistics and exceedence of the phosphorus objective at site WQ451 at Headingley on the Red River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.245	0.050	1.350	0.149	237	236	99.6%	0.246
1980	0.171	0.050	0.500	0.104	26	25	96.2%	0.176
1981	0.203	0.100	0.350	0.075	22	22	100.0%	0.203
1982	0.305	0.120	0.750	0.162	25	25	100.0%	0.305
1983	0.274	0.100	0.680	0.137	26	26	100.0%	0.274
1984	0.276	0.150	0.700	0.121	25	25	100.0%	0.276
1985	0.292	0.100	0.850	0.172	24	24	100.0%	0.292
1986	0.250	0.100	0.450	0.100	20	20	100.0%	0.250
1987	0.235	0.100	0.600	0.100	23	23	100.0%	0.235
1988	0.213	0.100	0.400	0.076	24	24	100.0%	0.213
1989	0.225	0.100	1.350	0.289	22	22	100.0%	0.225
JAN (80-89)	0.228	0.130	0.700	0.125	22	22	100.0%	0.228
FEB (80-89)	0.254	0.150	0.750	0.148	18	18	100.0%	0.254
MARCH (80-89)	0.224	0.100	0.500	0.101	21	21	100.0%	0.224
APRIL (80-89)	0.435	0.220	0.850	0.175	22	22	100.0%	0.435
MAY (80-89)	0.220	0.080	0.450	0.110	19	19	100.0%	0.220
JUNE (80-89)	0.236	0.050	0.500	0.100	19	18	94.7%	0.246
JULY (80-89)	0.229	0.100	0.500	0.110	20	20	100.0%	0.229
AUG (80-89)	0.232	0.100	0.400	0.086	20	20	100.0%	0.232
SEPT (80-89)	0.219	0.100	0.400	0.081	21	21	100.0%	0.219
OCT (80-89)	0.202	0.100	0.350	0.081	22	22	100.0%	0.202
NOV (80-89)	0.154	0.100	0.320	0.072	16	16	100.0%	0.154
DEC (80-89)	0.280	0.100	1.350	0.308	17	17	100.0%	0.280

TABLE A75: Phosphorus concentrations in the Assiniboine River, at site WQ453 at the Main Street Bridge.

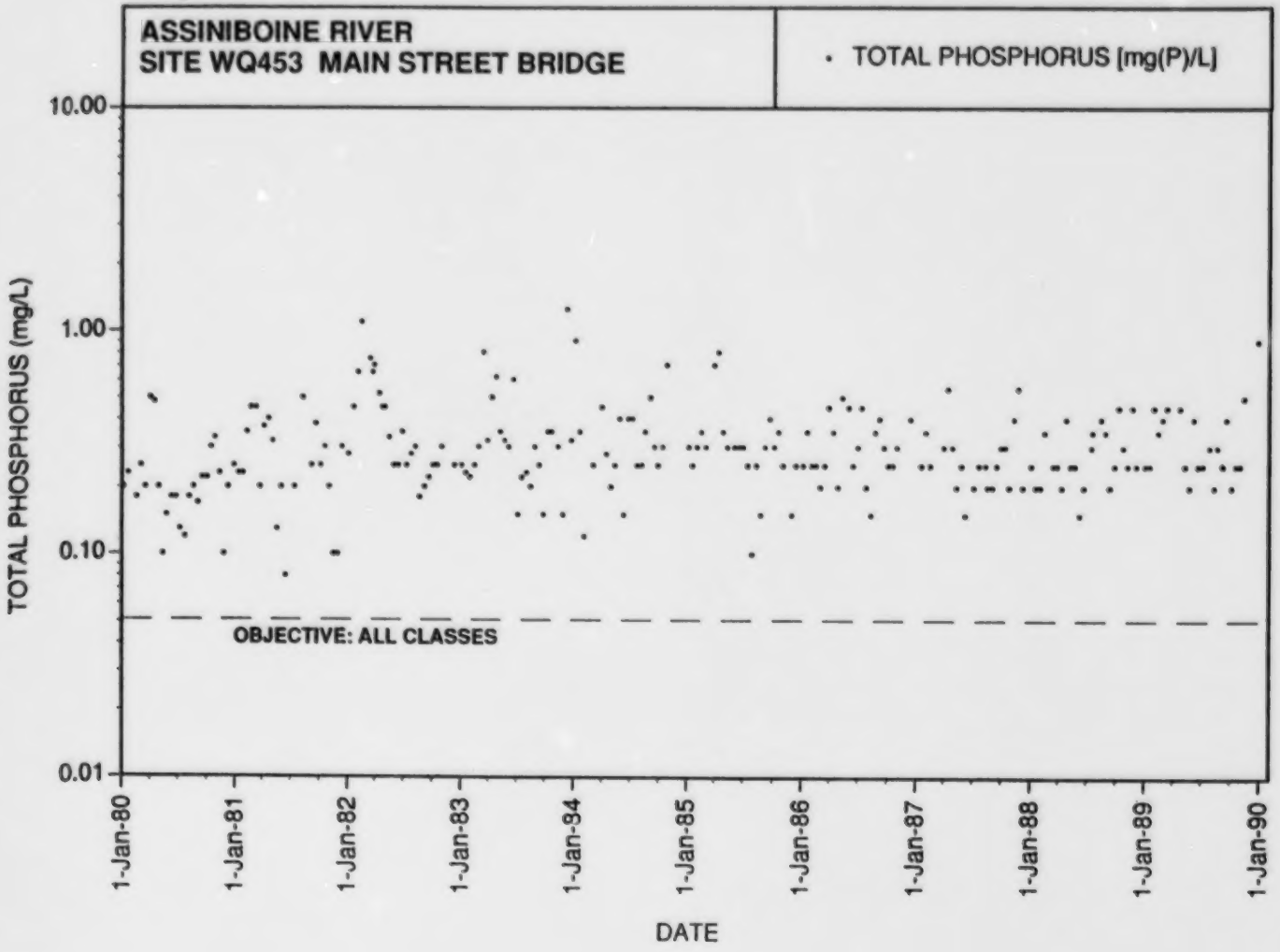


TABLE A45: Summary statistics and exceedence of the phosphorus objective at site WQ453 at the Main Street Bridge on the Red River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.313	0.080	1.250	0.161	230	230	100.0%	0.313
1980	0.219	0.100	0.500	0.096	26	26	100.0%	0.219
1981	0.272	0.080	0.500	0.120	22	22	100.0%	0.272
1982	0.403	0.180	1.100	0.225	24	24	100.0%	0.403
1983	0.357	0.150	1.250	0.238	26	26	100.0%	0.357
1984	0.353	0.120	0.900	0.184	20	20	100.0%	0.353
1985	0.317	0.100	0.800	0.153	23	23	100.0%	0.317
1986	0.309	0.150	0.500	0.096	23	23	100.0%	0.309
1987	0.281	0.150	0.550	0.107	21	21	100.0%	0.281
1988	0.283	0.150	0.450	0.085	23	23	100.0%	0.283
1989	0.341	0.200	0.900	0.156	22	22	100.0%	0.341
JAN (80-89)	0.302	0.200	0.900	0.154	21	21	100.0%	0.302
FEB (80-89)	0.351	0.120	1.100	0.227	17	17	100.0%	0.351
MARCH (80-89)	0.383	0.200	0.800	0.198	19	19	100.0%	0.383
APRIL (80-89)	0.433	0.200	0.800	0.154	22	22	100.0%	0.433
MAY (80-89)	0.274	0.100	0.500	0.105	19	19	100.0%	0.274
JUNE (80-89)	0.270	0.080	0.600	0.124	20	20	100.0%	0.270
JULY (80-89)	0.250	0.100	0.450	0.088	21	21	100.0%	0.250
AUG (80-89)	0.265	0.150	0.500	0.091	20	20	100.0%	0.265
SEPT (80-89)	0.280	0.150	0.500	0.090	21	21	100.0%	0.280
OCT (80-89)	0.305	0.200	0.700	0.106	22	22	100.0%	0.305
NOV (80-89)	0.289	0.100	0.550	0.136	15	15	100.0%	0.289
DEC (80-89)	0.371	0.100	1.250	0.329	13	13	100.0%	0.371

TABLE A76: Phosphorus concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

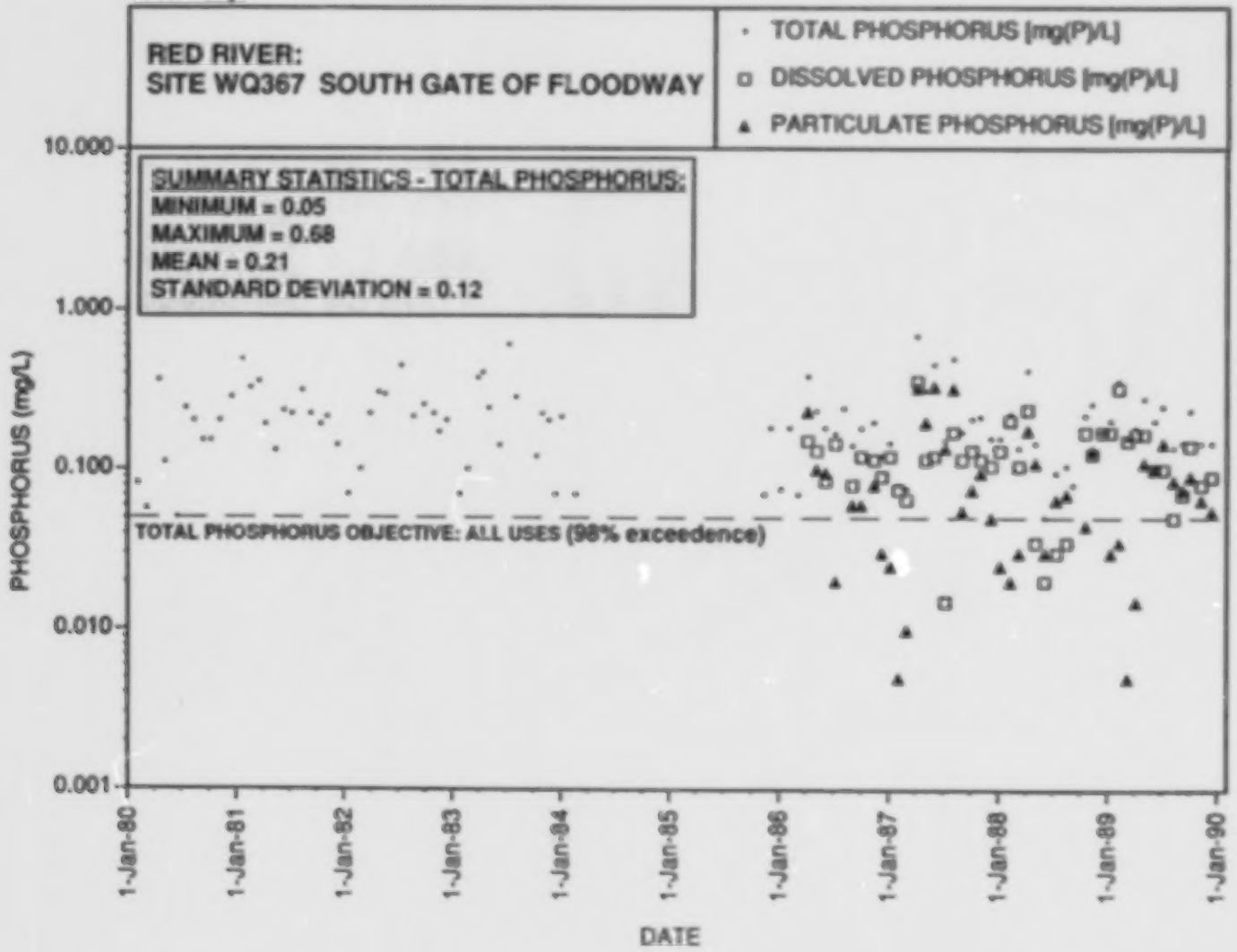


FIGURE A77: Phosphorus concentrations in the Red River, at site WQ445 at the south Floodway Control.

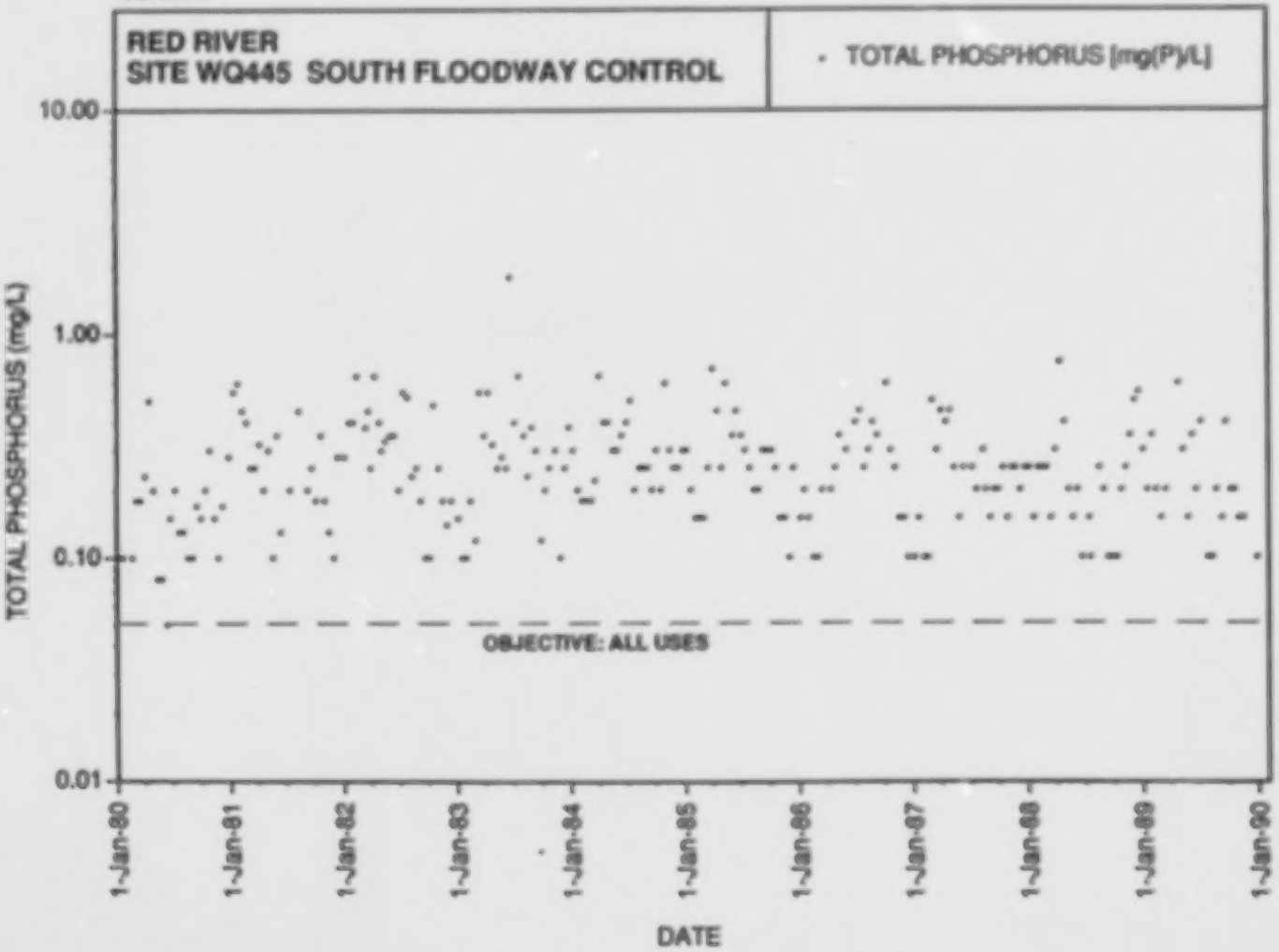


TABLE A46: Summary statistics and exceedence of the phosphorus objective at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.270	0.050	1.800	0.170	245	244	99.6%	0.271
1980	0.163	0.050	0.500	0.092	26	25	96.2%	0.167
1981	0.283	0.100	0.600	0.140	22	22	100.0%	0.283
1982	0.329	0.100	0.650	0.155	26	26	100.0%	0.329
1983	0.343	0.100	1.800	0.330	26	26	100.0%	0.343
1984	0.304	0.180	0.650	0.124	26	26	100.0%	0.304
1985	0.284	0.100	0.700	0.143	25	25	100.0%	0.284
1986	0.259	0.100	0.600	0.129	22	22	100.0%	0.259
1987	0.242	0.100	0.500	0.110	25	25	100.0%	0.242
1988	0.250	0.100	0.750	0.158	25	25	100.0%	0.250
1989	0.234	0.100	0.600	0.124	22	22	100.0%	0.234
JAN (80-89)	0.242	0.100	0.600	0.142	21	21	100.0%	0.242
FEB (80-89)	0.223	0.100	0.650	0.149	19	19	100.0%	0.223
MARCH (80-89)	0.265	0.100	0.550	0.123	24	24	100.0%	0.265
APRIL (80-89)	0.422	0.200	0.750	0.175	21	21	100.0%	0.422
MAY (80-89)	0.256	0.080	0.600	0.126	19	19	100.0%	0.256
JUNE (80-89)	0.346	0.050	1.800	0.369	19	18	94.7%	0.363
JULY (80-89)	0.312	0.100	0.650	0.159	21	21	100.0%	0.312
AUG (80-89)	0.249	0.100	0.450	0.094	20	20	100.0%	0.249
SEPT (80-89)	0.206	0.100	0.400	0.089	20	20	100.0%	0.206
OCT (80-89)	0.266	0.100	0.600	0.137	22	22	100.0%	0.266
NOV (80-89)	0.199	0.100	0.350	0.071	21	21	100.0%	0.199
DEC (80-89)	0.244	0.100	0.550	0.130	18	18	100.0%	0.244

FIGURE A78: Phosphorus concentrations in the Red River, at site WQ576 at the Fort Gary Bridge.

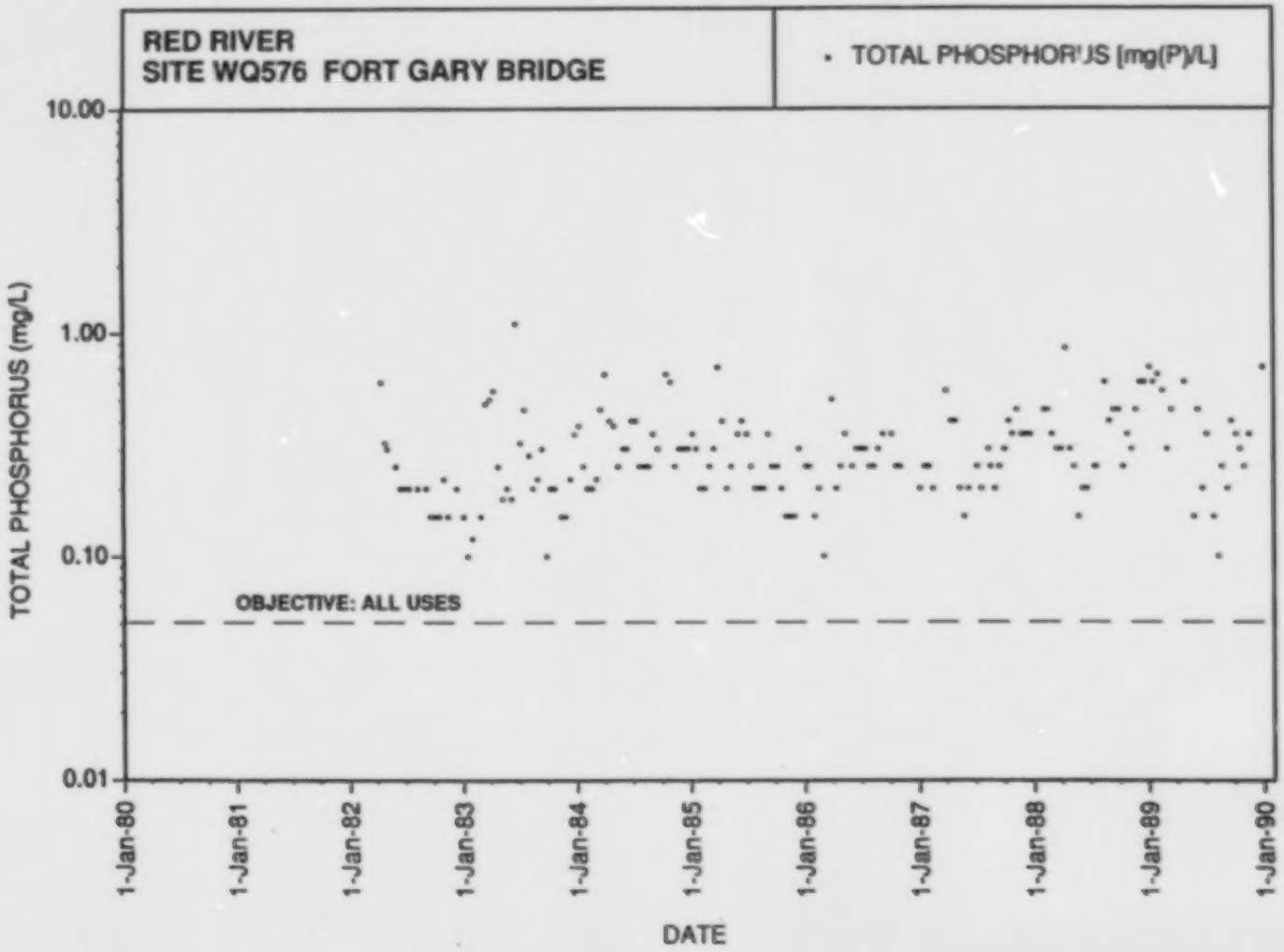


TABLE A47: Summary statistics and exceedence of the phosphorus objective, at site WQ578 at the Fort Gary Bridge on the Red River.

SITE: WQ578 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	0.311	0.100	1.100	0.152	177	177	100.0%	0.311
1980								
1981								
1982	0.228	0.150	0.600	0.112	16	16	100.0%	0.228
1983	0.290	0.100	1.100	0.215	24	24	100.0%	0.290
1984	0.343	0.200	0.650	0.129	25	25	100.0%	0.343
1985	0.276	0.150	0.700	0.116	25	25	100.0%	0.276
1986	0.270	0.100	0.500	0.083	20	20	100.0%	0.270
1987	0.296	0.150	0.550	0.100	23	23	100.0%	0.296
1988	0.380	0.150	0.850	0.166	23	23	100.0%	0.380
1989	0.383	0.100	0.700	0.189	21	21	100.0%	0.383
JAN (82-89)	0.341	0.100	0.700	0.192	13	13	100.0%	0.341
FEB (82-89)	0.264	0.120	0.550	0.138	12	12	100.0%	0.264
MARCH (82-89)	0.336	0.100	0.550	0.135	14	14	100.0%	0.336
APRIL (82-89)	0.445	0.200	0.850	0.189	17	17	100.0%	0.445
MAY (82-89)	0.239	0.150	0.380	0.077	13	13	100.0%	0.239
JUNE (82-89)	0.324	0.180	1.100	0.224	16	16	100.0%	0.324
JULY (82-89)	0.278	0.150	0.450	0.078	17	17	100.0%	0.278
AUG (82-89)	0.266	0.100	0.600	0.110	16	16	100.0%	0.266
SEPT (82-89)	0.288	0.100	0.450	0.102	16	16	100.0%	0.288
OCT (82-89)	0.313	0.150	0.650	0.144	16	16	100.0%	0.313
NOV (82-89)	0.261	0.150	0.450	0.105	15	15	100.0%	0.261
DEC (82-89)	0.368	0.150	0.700	0.173	12	12	100.0%	0.368

FIGURE A79: Phosphorus concentrations in the Red River, at site WQ449 at the north perimeter.

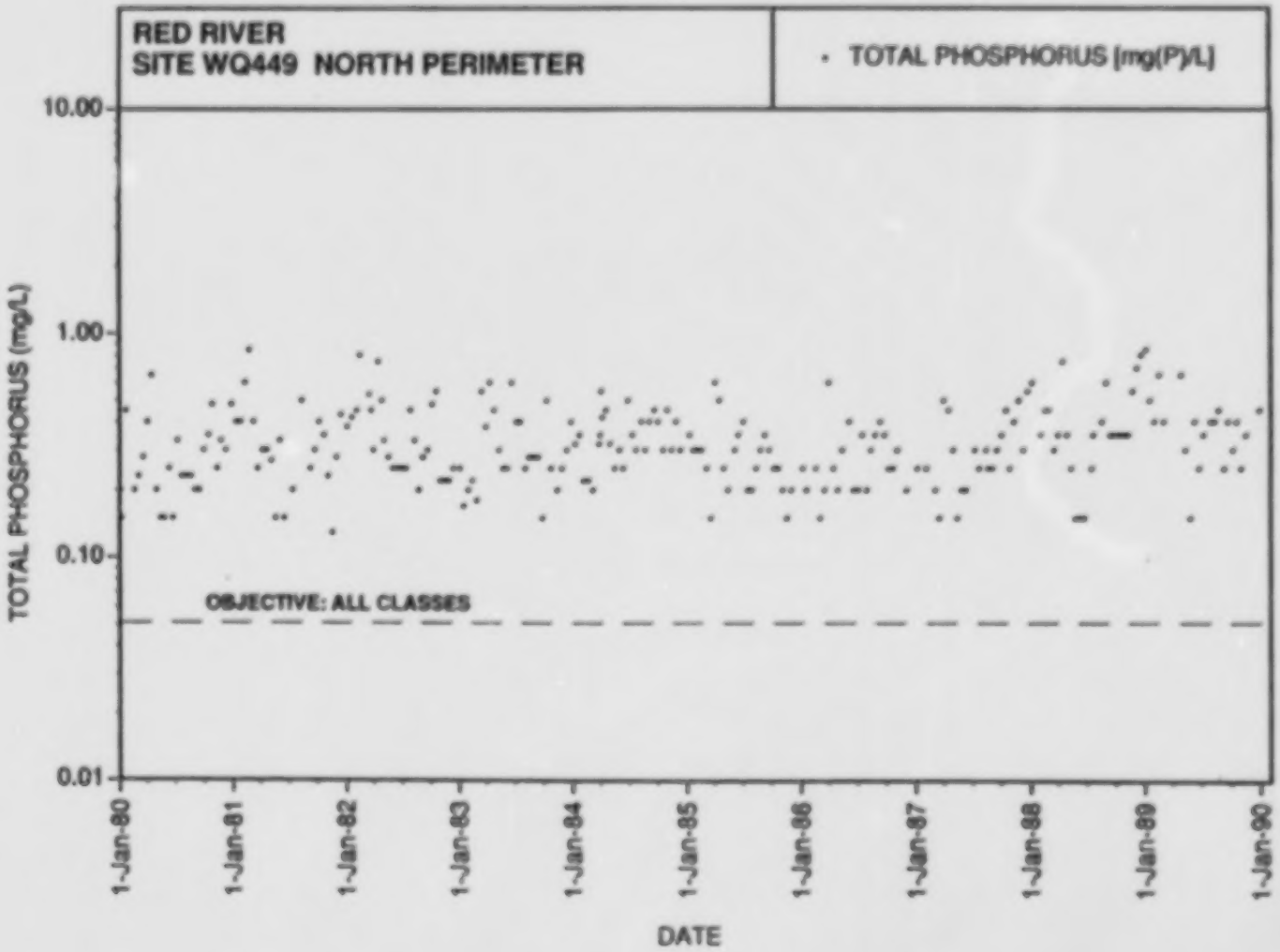


TABLE A48: Summary statistics and exceedence of the phosphorus objective, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.335	0.130	0.850	0.140	241	241	100.0%	0.335
1980	0.283	0.150	0.650	0.124	26	26	100.0%	0.283
1981	0.340	0.130	0.850	0.162	22	22	100.0%	0.340
1982	0.373	0.200	0.800	0.159	26	26	100.0%	0.373
1983	0.321	0.150	0.600	0.131	26	26	100.0%	0.321
1984	0.347	0.200	0.550	0.088	27	27	100.0%	0.347
1985	0.288	0.150	0.600	0.105	24	24	100.0%	0.288
1986	0.280	0.150	0.600	0.101	22	22	100.0%	0.280
1987	0.309	0.150	0.550	0.114	23	23	100.0%	0.309
1988	0.404	0.150	0.800	0.180	24	24	100.0%	0.404
1989	0.407	0.150	0.850	0.158	21	21	100.0%	0.407
JAN (80-89)	0.360	0.150	0.850	0.163	20	20	100.0%	0.360
FEB (80-89)	0.394	0.200	0.850	0.218	16	16	100.0%	0.394
MARCH (80-89)	0.313	0.150	0.550	0.123	24	24	100.0%	0.313
APRIL (80-89)	0.455	0.200	0.750	0.169	23	23	100.0%	0.455
MAY (80-89)	0.234	0.150	0.330	0.068	19	19	100.0%	0.234
JUNE (80-89)	0.282	0.150	0.600	0.120	20	20	100.0%	0.282
JULY (80-89)	0.303	0.200	0.450	0.082	21	21	100.0%	0.303
AUG (80-89)	0.330	0.200	0.600	0.102	20	20	100.0%	0.330
SEPT (80-89)	0.308	0.150	0.450	0.076	21	21	100.0%	0.308
OCT (80-89)	0.360	0.250	0.550	0.095	22	22	100.0%	0.360
NOV (80-89)	0.290	0.130	0.550	0.110	20	20	100.0%	0.290
DEC (80-89)	0.396	0.200	0.800	0.177	15	15	100.0%	0.396

FIGURE A80: Phosphorus concentrations in the Red River, at site WQ450 at Lockport.

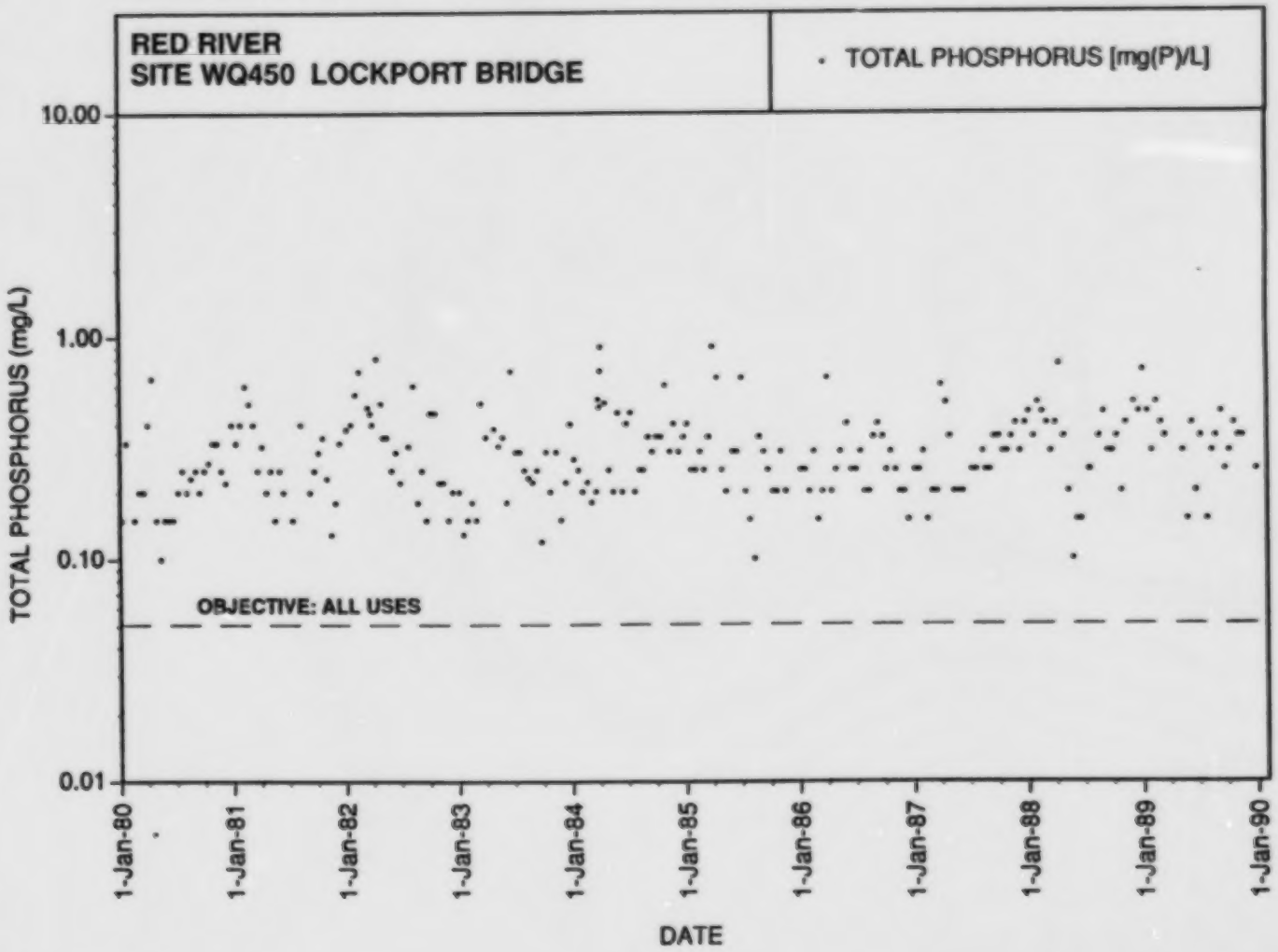


TABLE A49: Summary statistics and exceedence of the phosphorus objective, at site WQ450 at Lockport on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	0.312	0.100	0.900	0.143	245	245	100.0%	0.312
1980	0.243	0.100	0.650	0.115	26	26	100.0%	0.243
1981	0.290	0.130	0.600	0.119	22	22	100.0%	0.290
1982	0.373	0.150	0.800	0.170	25	25	100.0%	0.373
1983	0.273	0.120	0.700	0.130	25	25	100.0%	0.273
1984	0.358	0.180	0.900	0.168	29	29	100.0%	0.358
1985	0.312	0.100	0.900	0.176	25	25	100.0%	0.312
1986	0.274	0.150	0.650	0.109	23	23	100.0%	0.274
1987	0.298	0.150	0.600	0.102	25	25	100.0%	0.298
1988	0.348	0.100	0.750	0.143	24	24	100.0%	0.348
1989	0.345	0.150	0.700	0.123	21	21	100.0%	0.345
JAN (80-89)	0.318	0.130	0.700	0.136	19	19	100.0%	0.318
FEB (80-89)	0.345	0.150	0.700	0.172	19	19	100.0%	0.345
MARCH (80-89)	0.329	0.150	0.600	0.130	26	26	100.0%	0.329
APRIL (80-89)	0.493	0.150	0.900	0.235	21	21	100.0%	0.493
MAY (80-89)	0.241	0.100	0.450	0.096	19	19	100.0%	0.241
JUNE (80-89)	0.268	0.150	0.700	0.131	20	20	100.0%	0.268
JULY (80-89)	0.271	0.150	0.650	0.116	20	20	100.0%	0.271
AUG (80-89)	0.291	0.100	0.600	0.110	20	20	100.0%	0.291
SEPT (80-89)	0.280	0.120	0.450	0.079	21	21	100.0%	0.280
OCT (80-89)	0.318	0.200	0.600	0.096	22	22	100.0%	0.318
NOV (80-89)	0.274	0.130	0.400	0.086	20	20	100.0%	0.274
DEC (80-89)	0.297	0.150	0.500	0.101	18	18	100.0%	0.297

FIGURE 81: Phosphorus concentrations in the Red River, at site WQ142 at Selkirk.

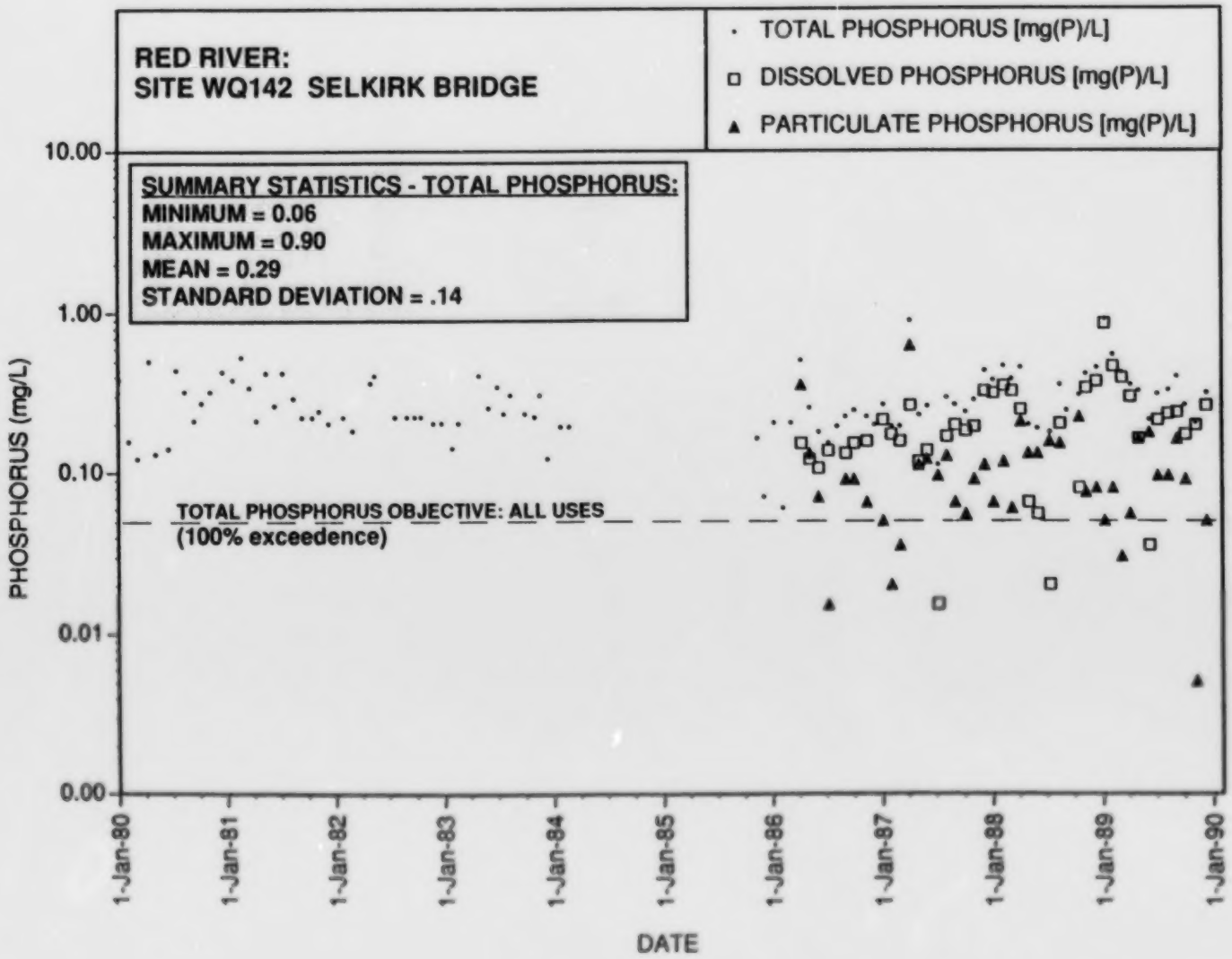


TABLE A50: Trend analysis and paired t-test results on phosphorus data.

TREND ANALYSIS RESULTS: PHOSPHORUS. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.00	0.979 N/S	INCREASING	167
WQ451 HEADINGLEY	0.00	0.659 N/S	INCREASING	282
WQ452 WEST PERIMETER	~	~ ~	~	~
WQ453 MAIN STREET BRIDGE	0.01	0.170 N/S	INCREASING	276
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.03	0.052 N/S	DECREASING	123
WQ445 FLOODWAY CONTROL	0.01	0.247 N/S	DECREASING	293
WQ576 FORT GARY BRIDGE	0.05	0.004 **	INCREASING	177
WQ447 NORWOOD BRIDGE	~	~ ~	~	~
WQ448 REDWOOD BRIDGE	~	~ ~	~	~
WQ449 NORTH PERIMETER	0.00	0.377 N/S	INCREASING	287
WQ450 LOCKPORT BRIDGE	0.00	0.362 N/S	DECREASING	294
WQ142 SELKIRK	0.00	0.578 N/S	INCREASING	198

PAIRED T-TEST RESULTS: PHOSPHORUS DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.000 **	-0.104	76
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.000 **	-0.078	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.017 *	-0.032	78

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

FIGURE A82: Percent saturation of oxygen in the Assinboine River, at site WQ018 at Headingley.

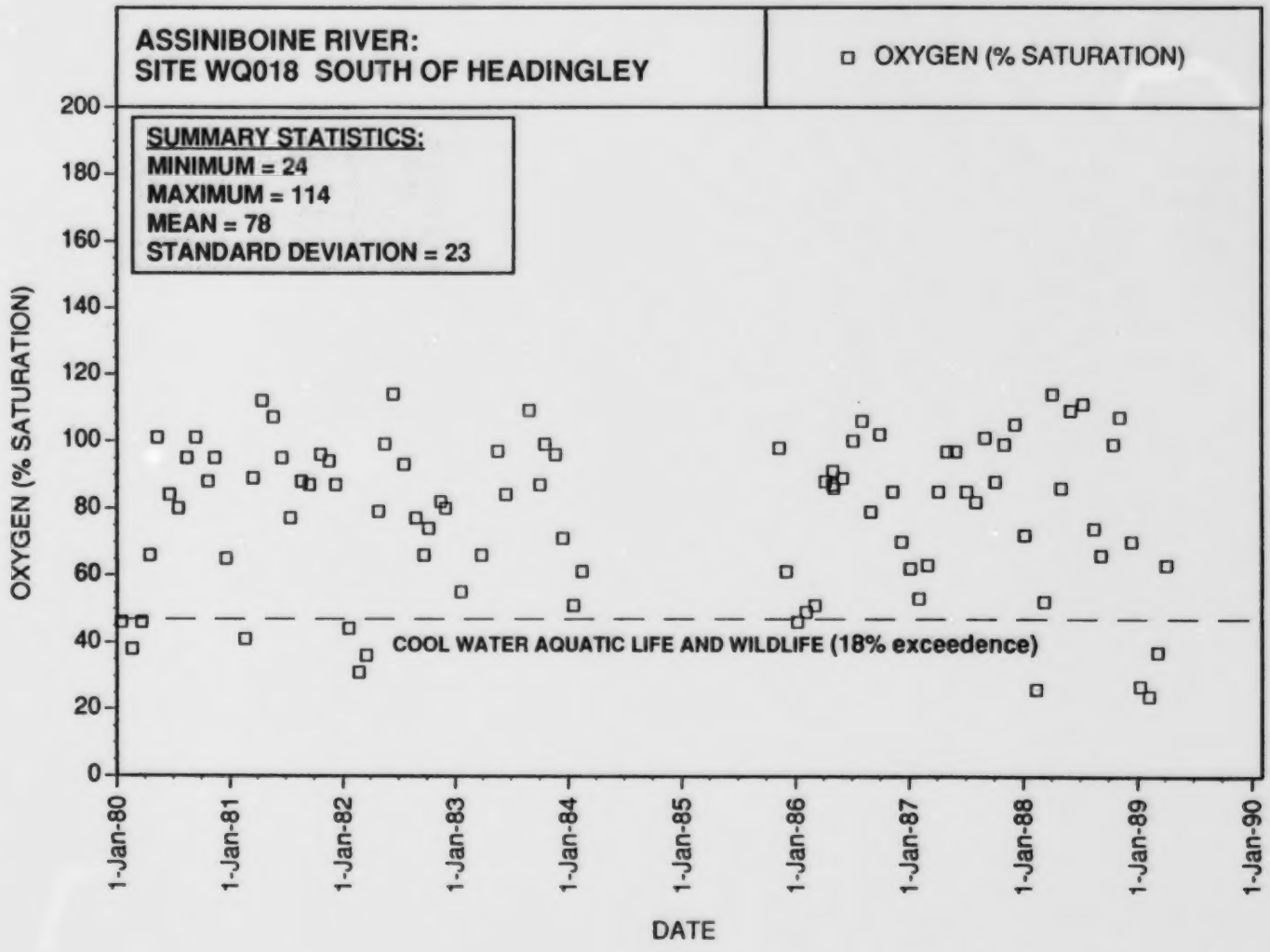


FIGURE A83: Percent saturation of oxygen in the Assinboine River, at site WQ451 at Headingley.

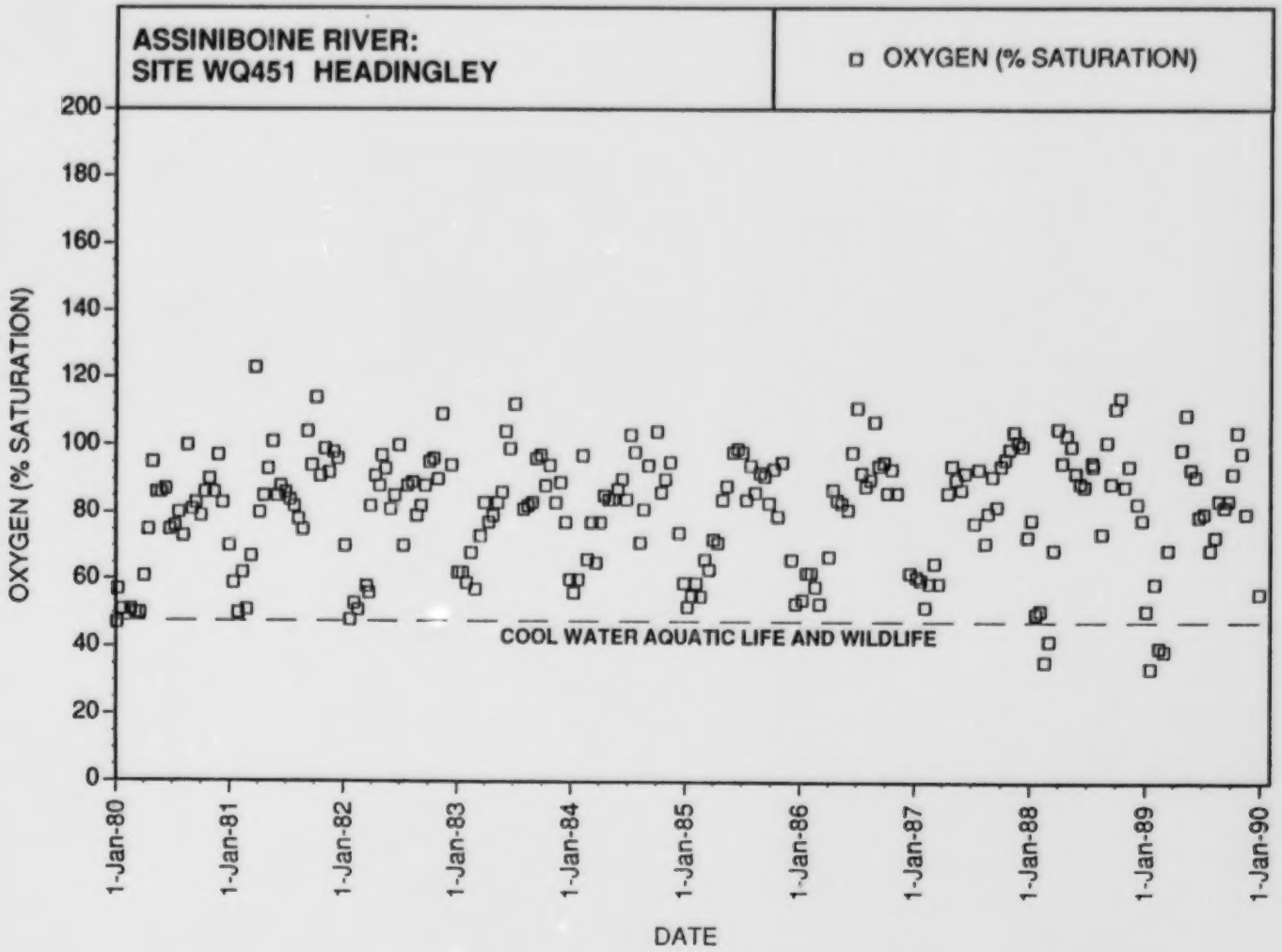


TABLE A51: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ451 at Headingley on the Assiniboine River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	81	34	123	17.1	241	5	2.1%	38
1980	75	47	100	15.9	26	0	0.0%	
1981	85	50	123	17.9	25	0	0.0%	
1982	81	48	109	16.7	25	0	0.0%	
1983	81	57	112	14.6	25	0	0.0%	
1984	82	56	104	13.8	24	0	0.0%	
1985	78	52	99	16.1	24	0	0.0%	
1986	82	53	111	17.0	22	0	0.0%	
1987	82	52	104	15.8	24	0	0.0%	
1988	84	36	114	21.1	24	2	8.3%	39
1989	76	34	109	21.5	22	3	13.6%	38
JAN (80-89)	56	34	78	8.8	22	1	4.5%	34
FEB (80-89)	57	36	97	12.8	18	2	11.1%	38
MARCH (80-89)	67	39	123	19.2	22	2	9.1%	41
APRIL (80-89)	83	61	103	10.8	22	0	0.0%	
MAY (80-89)	91	83	109	7.0	19	0	0.0%	
JUNE (80-89)	89	75	104	7.8	21	0	0.0%	
JULY (80-89)	89	69	112	11.9	21	0	0.0%	
AUG (80-89)	83	71	107	10.1	21	0	0.0%	
SEPT (80-89)	91	81	111	8.0	20	0	0.0%	
OCT (80-89)	94	79	114	9.2	22	0	0.0%	
NOV (80-89)	94	80	109	7.8	16	0	0.0%	
DEC (80-89)	75	53	100	15.2	17	0	0.0%	

FIGURE A84: Percent saturation of oxygen in the Assinboine River, at site WQ452 at the west perimeter.

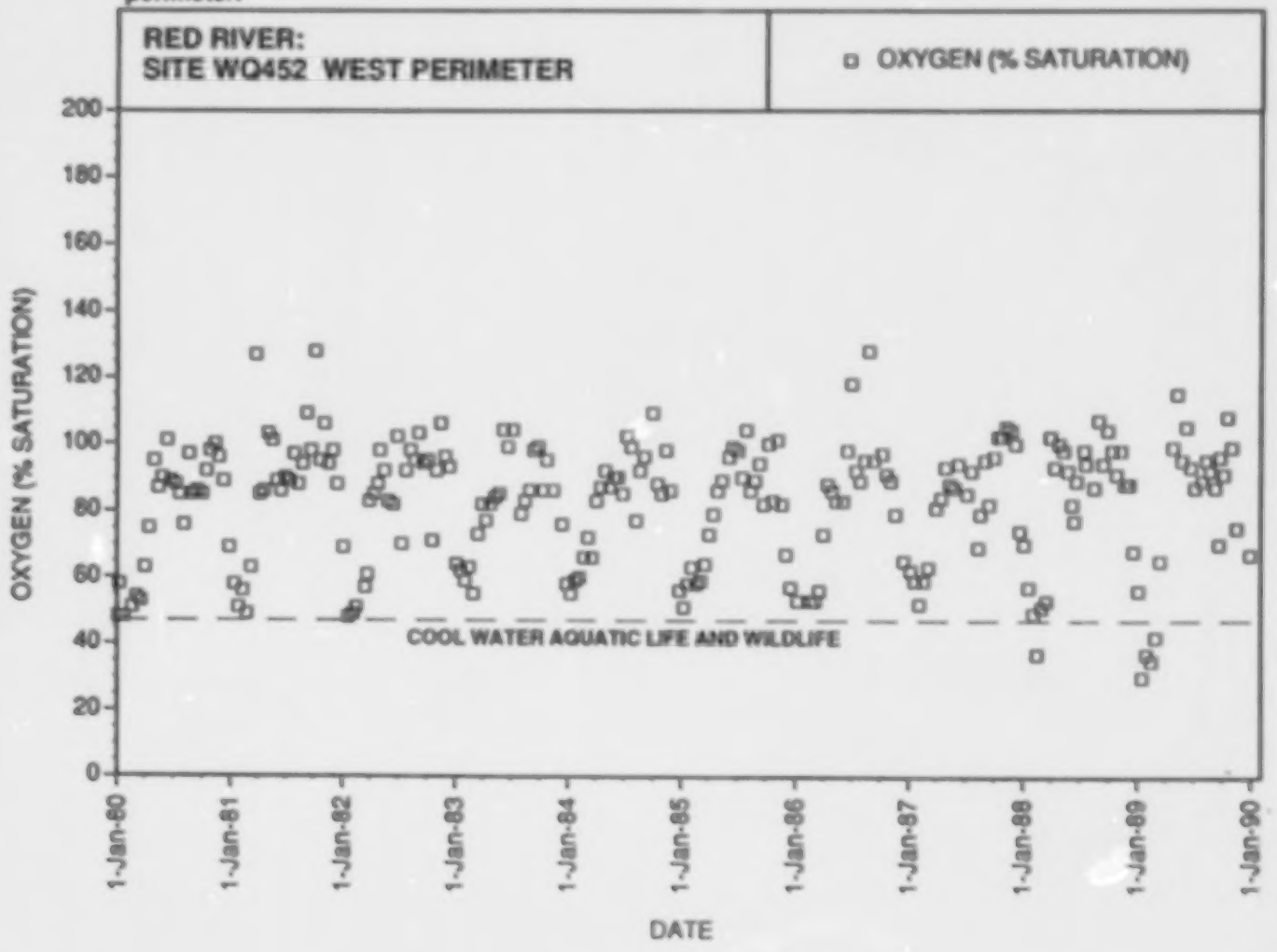


TABLE A52: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ452 at the west perimeter on the Assiniboine River.

SITE: WQ452 ASSINIBOINE RIVER AT THE WEST PERIMETER
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	83	30	128	18.3	244	5	2.0%	36
1980	79	48	101	17.6	26	0	0.0%	
1981	89	49	128	20.5	25	0	0.0%	
1982	83	48	106	17.6	26	0	0.0%	
1983	81	55	104	14.8	24	0	0.0%	
1984	83	55	109	15.3	24	0	0.0%	
1985	80	51	104	16.4	25	0	0.0%	
1986	84	53	128	20.1	21	0	0.0%	
1987	84	52	105	15.9	24	0	0.0%	
1988	83	37	107	19.4	26	1	3.8%	37
1989	79	30	115	24.8	23	4	17.4%	36
JAN (80-89)	55	30	70	9.5	21	2	9.5%	34
FEB (80-89)	54	35	66	8.5	17	2	11.8%	36
MARCH (80-89)	67	42	127	18.7	23	1	4.3%	42
APRIL (80-89)	85	63	100	8.9	22	0	0.0%	
MAY (80-89)	92	83	115	7.9	19	0	0.0%	
JUNE (80-89)	92	77	105	8.0	22	0	0.0%	
JULY (80-89)	93	70	118	9.6	21	0	0.0%	
AUG (80-89)	90	69	128	12.4	21	0	0.0%	
SEPT (80-89)	93	70	109	8.9	20	0	0.0%	
OCT (80-89)	95	71	128	11.4	22	0	0.0%	
NOV (80-89)	94	75	106	9.1	20	0	0.0%	
DEC (80-89)	76	56	100	14.8	16	0	0.0%	

FIGURE A85: Percent saturation of oxygen in the Assinboine River, at site WQ453 at the Main Street Bridge.

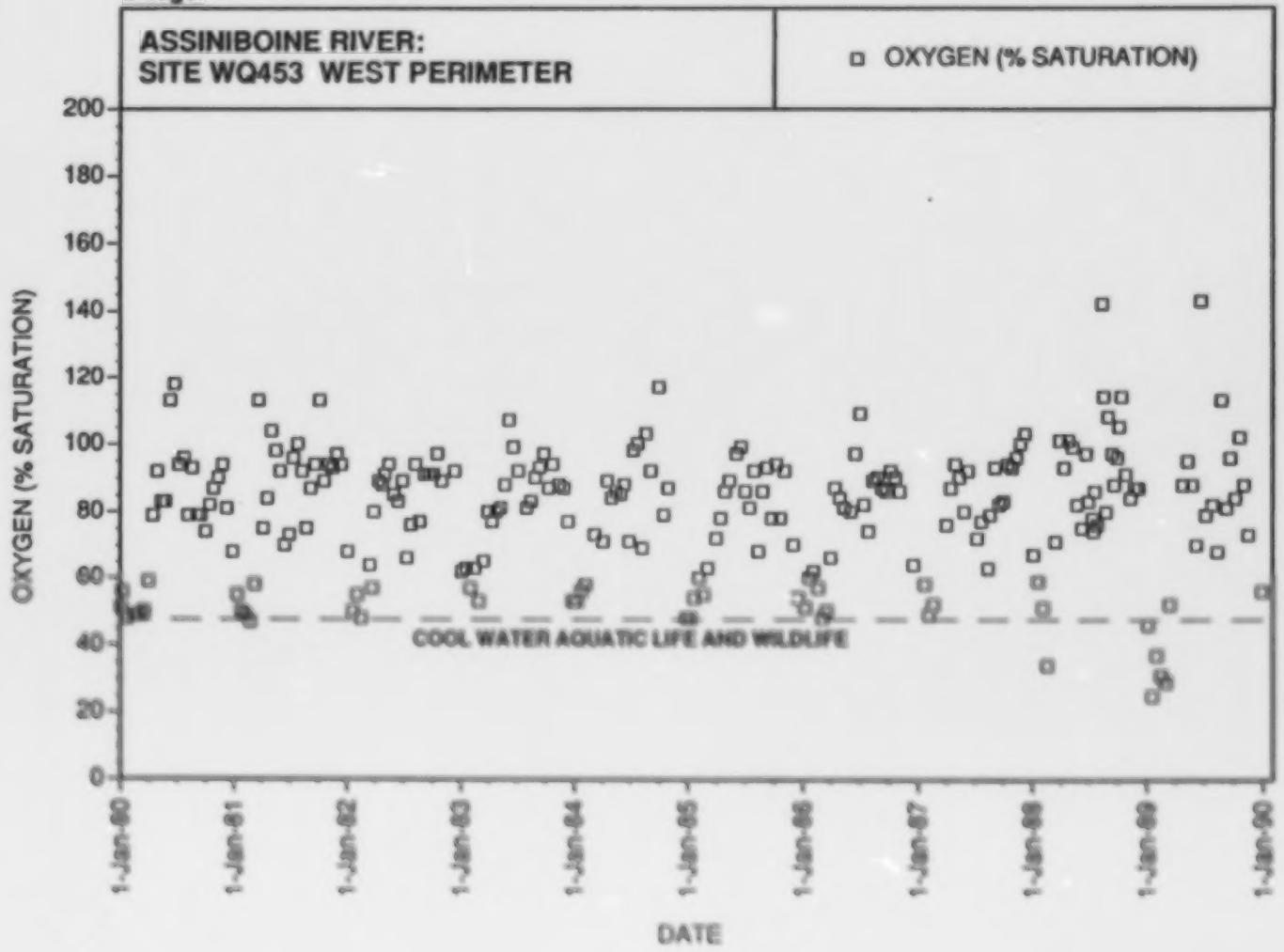


TABLE A53: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ453 at the Main Street Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	80	25	143	18.9	239	6	2.5%	34
1980	78	48	118	19.4	26	0	0.0%	
1981	84	47	113	19.5	25	0	0.0%	
1982	79	48	97	15.2	24	0	0.0%	
1983	80	53	107	14.9	25	0	0.0%	
1984	80	48	117	18.0	20	0	0.0%	
1985	77	48	99	15.5	23	0	0.0%	
1986	77	48	109	16.6	23	0	0.0%	
1987	82	49	103	15.5	21	0	0.0%	
1988	87	34	142	20.6	30	1	3.3%	34
1989	74	25	143	29.4	22	5	22.7%	34
JAN (80-89)	53	25	68	9.7	21	3	14.3%	36
FEB (80-89)	52	31	63	8.7	17	2	11.8%	33
MARCH (80-89)	65	29	113	19.7	19	1	5.3%	29
APRIL (80-89)	83	59	101	9.9	22	0	0.0%	
MAY (80-89)	88	80	104	6.9	19	0	0.0%	
JUNE (80-89)	92	70	143	17.7	22	0	0.0%	
JULY (80-89)	85	66	109	11.1	23	0	0.0%	
AUG (80-89)	89	63	142	18.2	23	0	0.0%	
SEPT (80-89)	89	78	97	6.3	21	0	0.0%	
OCT (80-89)	93	74	117	11.3	23	0	0.0%	
NOV (80-89)	89	73	100	6.2	15	0	0.0%	
DEC (80-89)	75	48	103	18.2	14	0	0.0%	

FIGURE A86: Percent saturation of oxygen in the Red River, at site WQ367 at the south gate of the Floodway.

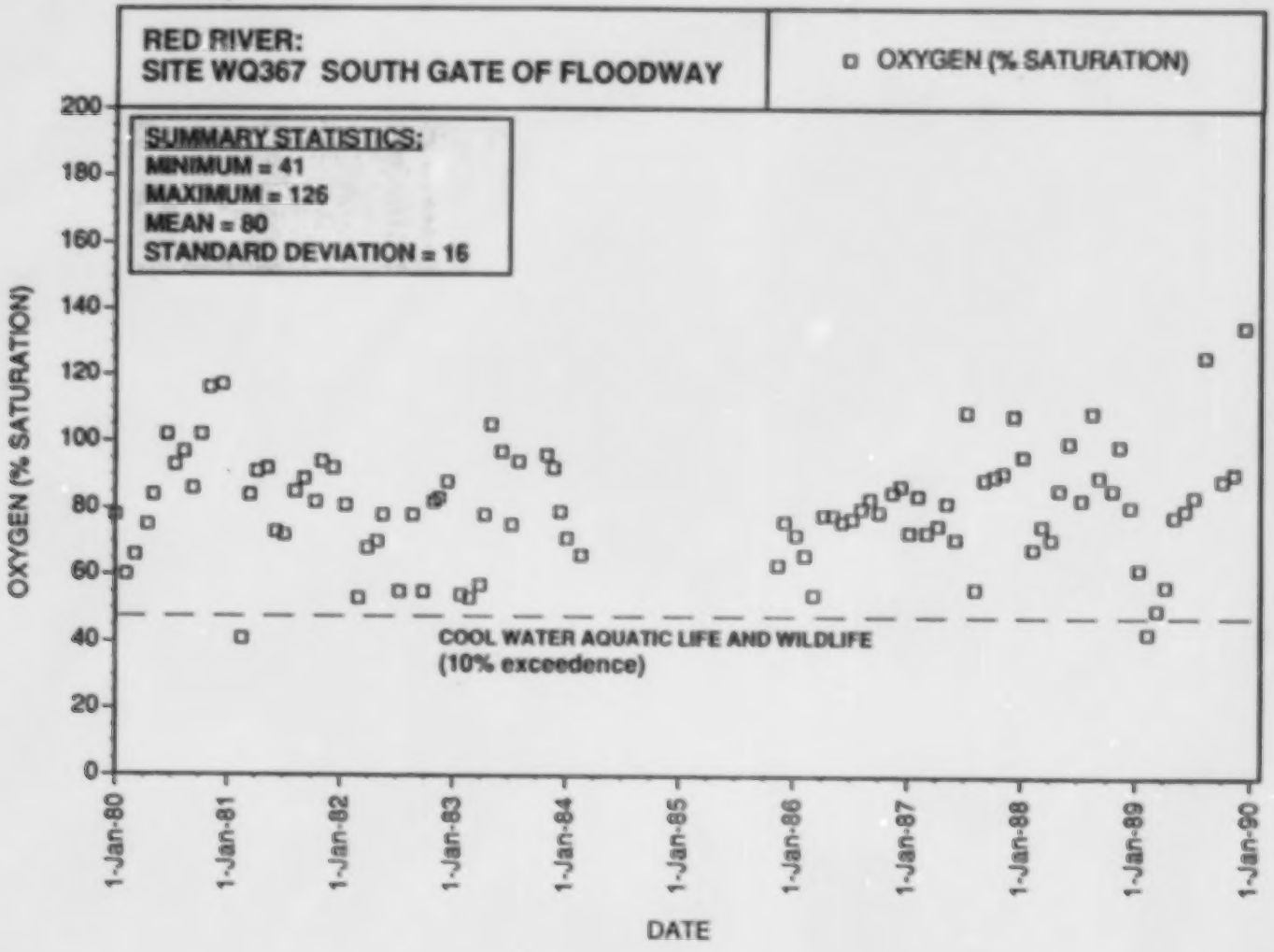


FIGURE A87: Percent saturation of oxygen in the Red River, at site WQ445 at the south Floodway control.

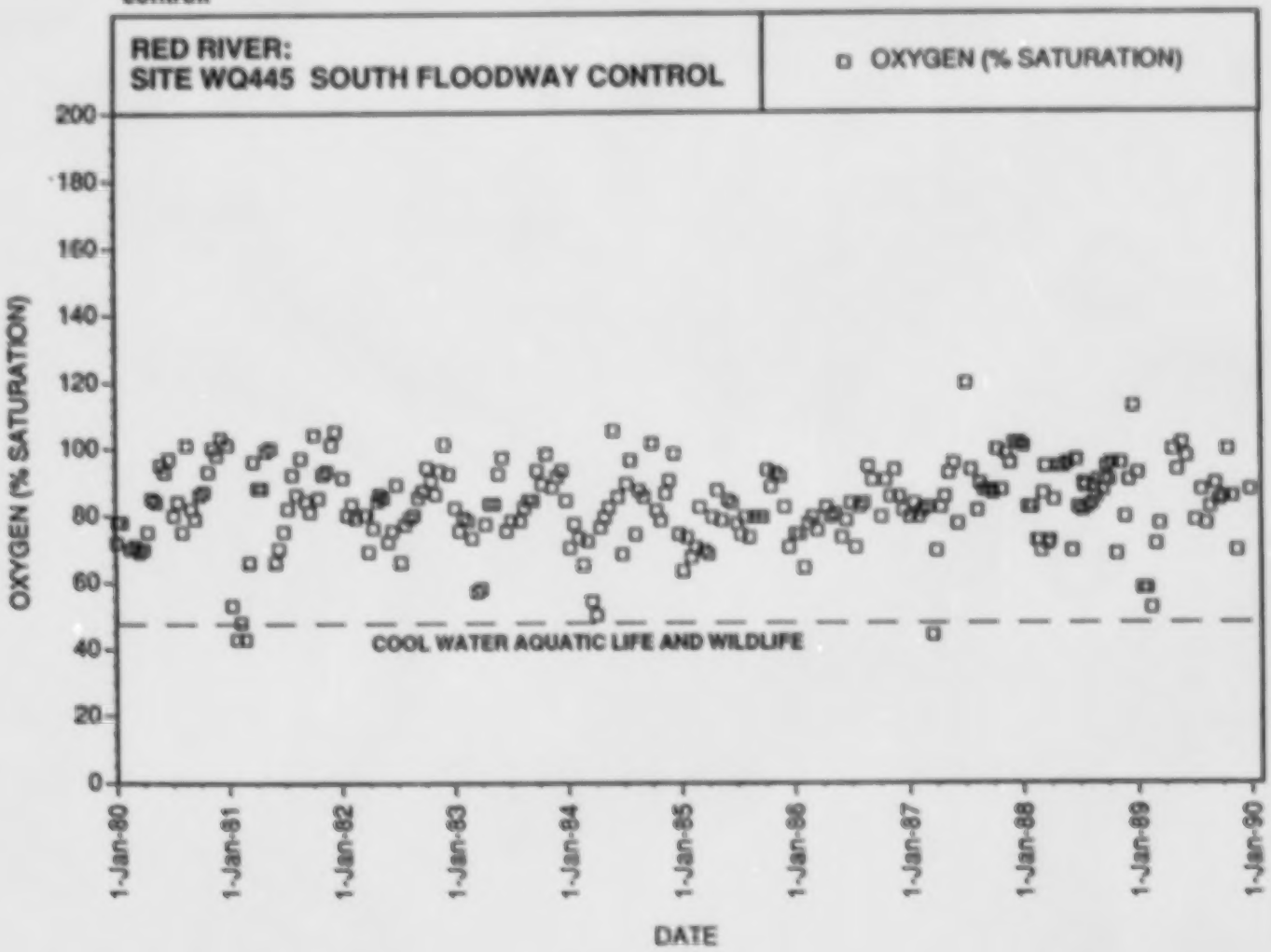


TABLE A54: **Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ445 at the south Floodway control on the Red River.**

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	82.6	43.0	119.0	11.9	256	3	1.2%	43.3
1980	84.8	69.0	103.0	11.0	26	0	0.0%	
1981	81.5	43.0	105.0	18.9	25	2	8.0%	43.0
1982	83.0	66.0	101.0	8.1	26	0	0.0%	
1983	82.0	57.0	98.0	10.1	25	0	0.0%	
1984	79.8	50.0	105.0	13.3	25	0	0.0%	
1985	78.4	63.0	93.0	8.1	25	0	0.0%	
1986	80.4	64.0	94.0	7.2	23	0	0.0%	
1987	86.8	44.0	119.0	13.6	25	1	4.0%	44.0
1988	85.7	68.0	112.0	10.0	35	0	0.0%	
1989	81.9	52.0	101.0	14.0	21	0	0.0%	
JAN (80-89)	74.0	43.0	100.0	13.4	21	1	4.8%	43.0
FEB (80-89)	70.8	43.0	83.0	11.6	20	1	5.0%	43.0
MARCH (80-89)	72.5	44.0	96.0	11.4	26	1	3.8%	44.0
APRIL (80-89)	80.5	50.0	99.0	10.1	21	0	0.0%	
MAY (80-89)	90.4	78.0	105.0	8.1	19	0	0.0%	
JUNE (80-89)	81.0	66.0	97.0	10.4	21	0	0.0%	
JULY (80-89)	83.7	66.0	119.0	10.5	23	0	0.0%	
AUG (80-89)	83.8	73.0	101.0	7.1	23	0	0.0%	
SEPT (80-89)	85.6	79.0	94.0	4.3	20	0	0.0%	
OCT (80-89)	89.5	68.0	104.0	8.3	23	0	0.0%	
NOV (80-89)	90.5	69.0	101.0	7.3	21	0	0.0%	
DEC (80-89)	92.2	70.0	112.0	11.4	18	0	0.0%	

FIGURE A88: Percent saturation of oxygen in the Red River, at site WQ576 at the Fort Gary Bridge.

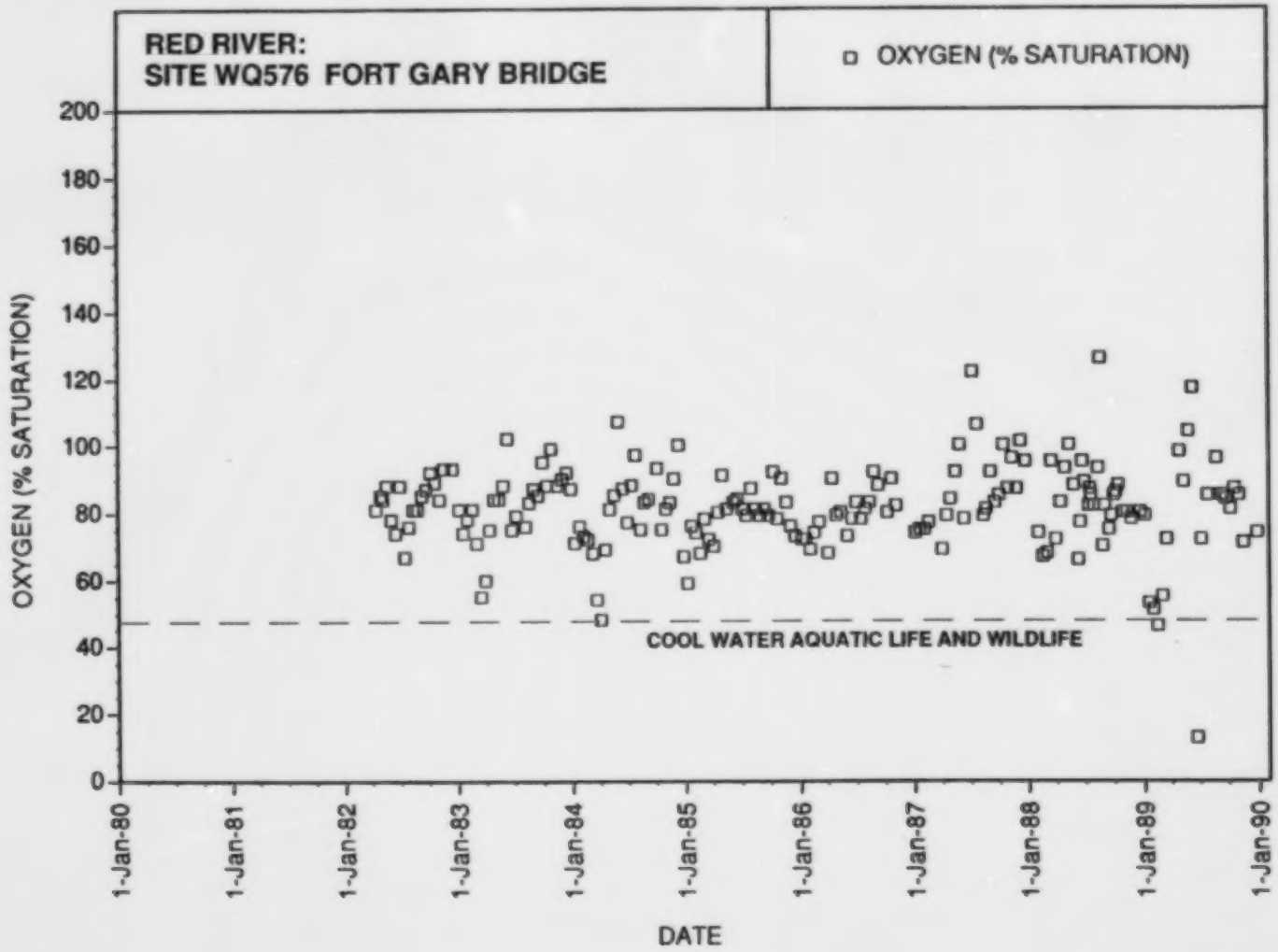


TABLE A55: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ576 at the Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	81.4	13.0	126.0	12.7	187	2	1.1%	29.5
1980								
1981								
1982	83.5	67.0	93.0	6.7	19	0	0.0%	
1983	82.3	55.0	102.0	10.9	24	0	0.0%	
1984	79.4	48.0	107.0	13.3	25	0	0.0%	
1985	79.0	59.0	92.0	7.4	25	0	0.0%	
1986	79.5	68.0	92.0	7.0	20	0	0.0%	
1987	87.7	69.0	122.0	12.5	23	0	0.0%	
1988	83.5	66.0	126.0	11.8	30	0	0.0%	
1989	76.0	13.0	117.0	22.9	21	2	9.5%	29.5
JAN (82-89)	70.2	51.0	81.0	9.6	13	0	0.0%	
FEB (82-89)	71.4	46.0	81.0	8.6	13	1	7.7%	46.0
MARCH (82-89)	69.0	54.0	95.0	10.9	14	0	0.0%	
APRIL (82-89)	79.8	48.0	98.0	11.7	17	0	0.0%	
MAY (82-89)	90.1	80.0	107.0	8.7	15	0	0.0%	
JUNE (82-89)	79.7	13.0	117.0	20.5	18	1	5.6%	13.0
JULY (82-89)	85.1	67.0	122.0	12.3	19	0	0.0%	
AUG (82-89)	84.9	70.0	126.0	12.1	18	0	0.0%	
SEPT (82-89)	84.5	75.0	95.0	4.8	16	0	0.0%	
OCT (82-89)	87.0	75.0	100.0	6.9	18	0	0.0%	
NOV (82-89)	85.3	71.0	96.0	6.3	15	0	0.0%	
DEC (82-89)	85.3	67.0	101.0	11.8	11	0	0.0%	

FIGURE A89: Percent saturation of oxygen in the Red River, at site WQ447 at the Norwood Bridge.

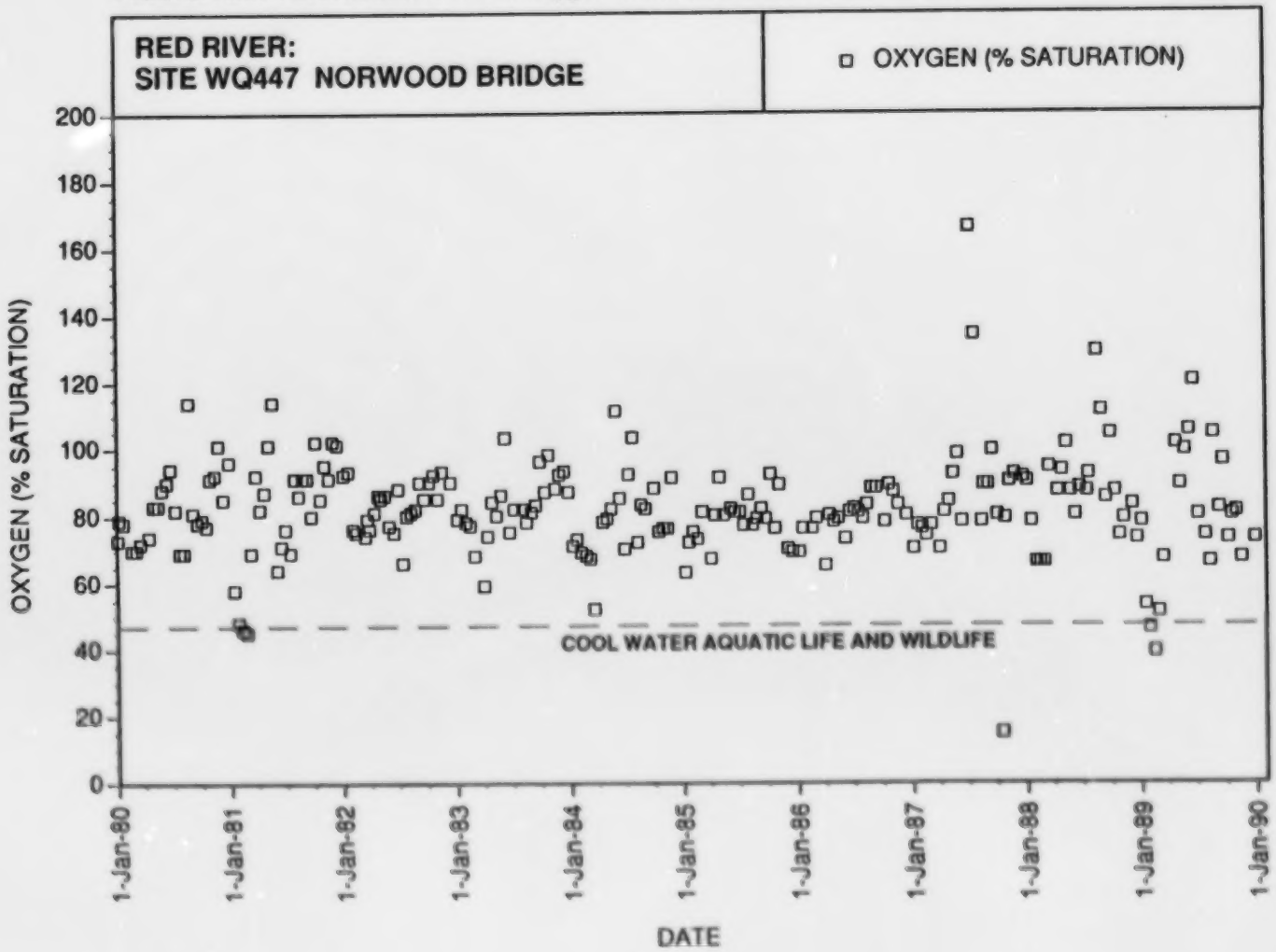


TABLE A56: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ447 at the Norwood Bridge on the Red River.

SITE: WQ447 RED RIVER AT THE NORWOOD BRIDGE
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	82.0	15.0	166.0	14.8	233	5	2.1%	38.2
1980	82.7	69.0	114.0	11.1	25	0	0.0%	
1981	81.5	45.0	114.0	18.7	25	2	8.0%	45.5
1982	83.1	66.0	93.0	7.2	25	0	0.0%	
1983	83.0	59.0	103.0	9.6	24	0	0.0%	
1984	79.2	52.0	111.0	12.8	22	0	0.0%	
1985	78.3	63.0	92.0	7.3	23	0	0.0%	
1986	79.7	65.0	89.0	6.0	21	0	0.0%	
1987	86.0	15.0	166.0	26.4	23	1	4.3%	15.0
1988	87.0	66.0	129.0	14.8	23	0	0.0%	
1989	78.4	39.0	120.0	20.7	22	2	9.1%	42.5
JAN (80-89)	72.4	46.0	93.0	13.0	21	1	4.8%	46.0
FEB (80-89)	68.2	39.0	78.0	12.1	18	3	16.7%	43.3
MARCH (80-89)	71.7	51.0	94.0	11.1	19	0	0.0%	
APRIL (80-89)	81.8	65.0	101.0	8.3	20	0	0.0%	
MAY (80-89)	90.5	79.0	114.0	10.6	19	0	0.0%	
JUNE (80-89)	83.6	64.0	120.0	13.2	21	0	0.0%	
JULY (80-89)	88.2	66.0	166.0	22.8	21	0	0.0%	
AUG (80-89)	86.8	66.0	129.0	15.6	21	0	0.0%	
SEPT (80-89)	86.8	78.0	104.0	7.5	19	0	0.0%	
OCT (80-89)	81.0	15.0	102.0	16.8	22	1	4.5%	15.0
NOV (80-89)	87.3	67.0	101.0	7.9	18	0	0.0%	
DEC (80-89)	85.2	69.0	102.0	11.1	14	0	0.0%	

FIGURE A90: Percent saturation of oxygen in the Red River, at site WQ448 at the Redwood Bridge.

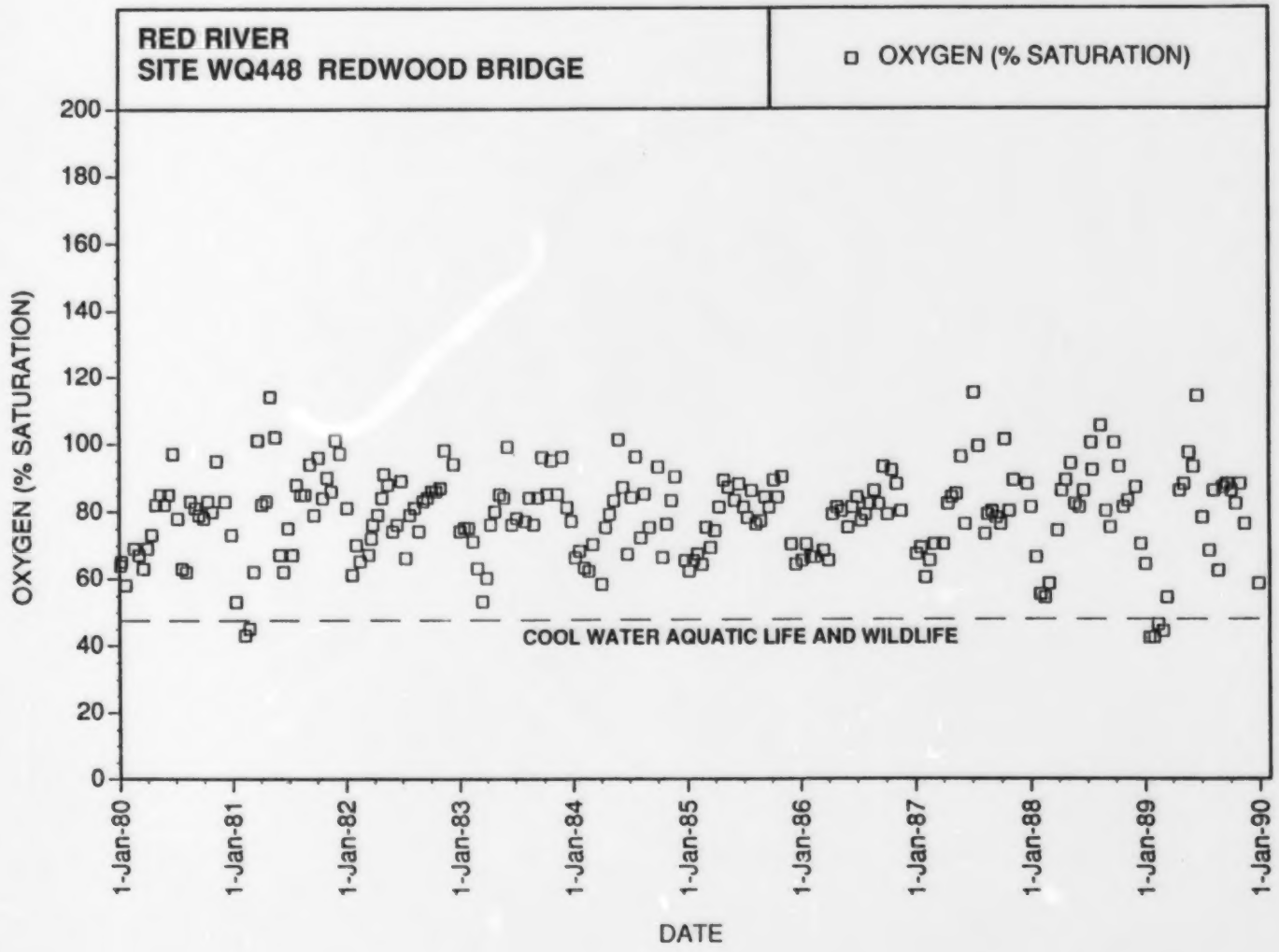


TABLE A57: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ448 at the Redwood Bridge on the Red River.

SITE: WQ448 RED RIVER AT THE REDWOOD BRIDGE
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	78.5	42.0	115.0	13.0	235	6	2.6%	43.7
1980	75.9	58.0	97.0	10.3	25	0	0.0%	
1981	80.9	43.0	114.0	18.5	24	2	8.3%	44.0
1982	79.6	61.0	98.0	9.5	25	0	0.0%	
1983	79.4	53.0	99.0	10.9	25	0	0.0%	
1984	76.7	58.0	101.0	11.8	23	0	0.0%	
1985	77.7	62.0	90.0	9.0	24	0	0.0%	
1986	78.1	65.0	93.0	8.4	22	0	0.0%	
1987	81.0	60.0	115.0	13.2	22	0	0.0%	
1988	81.4	54.0	105.0	13.9	23	0	0.0%	
1989	74.0	42.0	114.0	20.0	22	4	18.2%	43.5
JAN (80-89)	64.6	42.0	81.0	10.3	20	2	10.0%	42.0
FEB (80-89)	61.7	43.0	75.0	9.1	19	3	15.8%	44.7
MARCH (80-89)	66.8	44.0	101.0	11.4	20	1	5.0%	44.0
APRIL (80-89)	79.0	58.0	89.0	7.6	22	0	0.0%	
MAY (80-89)	89.6	79.0	114.0	9.0	19	0	0.0%	
JUNE (80-89)	82.4	62.0	114.0	12.1	21	0	0.0%	
JULY (80-89)	82.7	63.0	115.0	12.6	21	0	0.0%	
AUG (80-89)	79.5	62.0	105.0	9.1	21	0	0.0%	
SEPT (80-89)	84.0	75.0	100.0	7.1	20	0	0.0%	
OCT (80-89)	85.2	66.0	101.0	7.8	22	0	0.0%	
NOV (80-89)	87.8	76.0	98.0	5.8	16	0	0.0%	
DEC (80-89)	79.1	58.0	101.0	13.2	14	0	0.0%	

FIGURE A91: Percent saturation of oxygen in the Red River, at site WQ449 at the north perimeter.

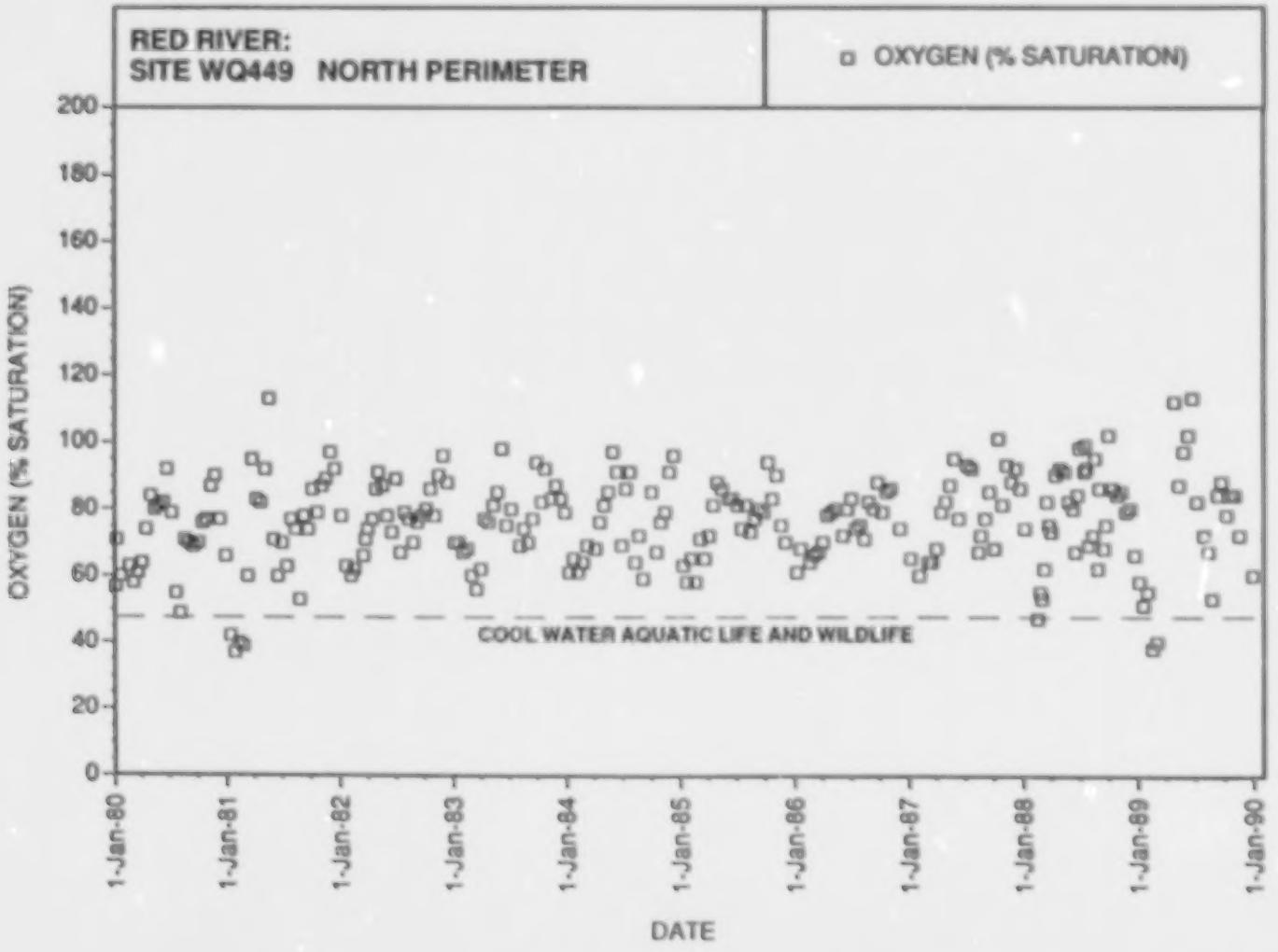


TABLE A58: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	76.2	37.0	113.0	13.3	249	6	2.4%	39.3
1980	71.7	49.0	92.0	11.2	26	0	0.0%	
1981	73.3	37.0	113.0	20.0	25	4	16.0%	39.5
1982	77.7	60.0	96.0	9.6	26	0	0.0%	
1983	76.6	56.0	98.0	10.4	25	0	0.0%	
1984	76.2	59.0	97.0	12.1	23	0	0.0%	
1985	76.3	58.0	94.0	9.7	24	0	0.0%	
1986	75.5	61.0	88.0	7.5	22	0	0.0%	
1987	79.8	60.0	101.0	12.0	23	0	0.0%	
1988	78.9	47.0	102.0	13.6	34	0	0.0%	
1989	75.1	38.0	113.0	21.6	21	2	9.5%	39.0
JAN (80-89)	61.4	37.0	78.0	10.0	20	2	10.0%	39.5
FEB (80-89)	56.9	38.0	68.0	10.2	16	3	18.8%	39.0
MARCH (80-89)	65.9	40.0	95.0	10.4	24	1	4.2%	40.0
APRIL (80-89)	80.5	64.0	112.0	9.9	22	0	0.0%	
MAY (80-89)	88.3	80.0	113.0	8.2	19	0	0.0%	
JUNE (80-89)	82.0	60.0	113.0	12.7	23	0	0.0%	
JULY (80-89)	79.8	55.0	99.0	10.6	23	0	0.0%	
AUG (80-89)	70.4	49.0	95.0	10.3	23	0	0.0%	
SEPT (80-89)	78.5	59.0	102.0	9.6	21	0	0.0%	
OCT (80-89)	82.5	67.0	101.0	7.4	23	0	0.0%	
NOV (80-89)	85.5	72.0	96.0	6.2	20	0	0.0%	
DEC (80-89)	80.4	60.0	97.0	11.6	15	0	0.0%	

FIGURE A82: Percent saturation of oxygen in the Red River, at site WQ450 at Lockport.

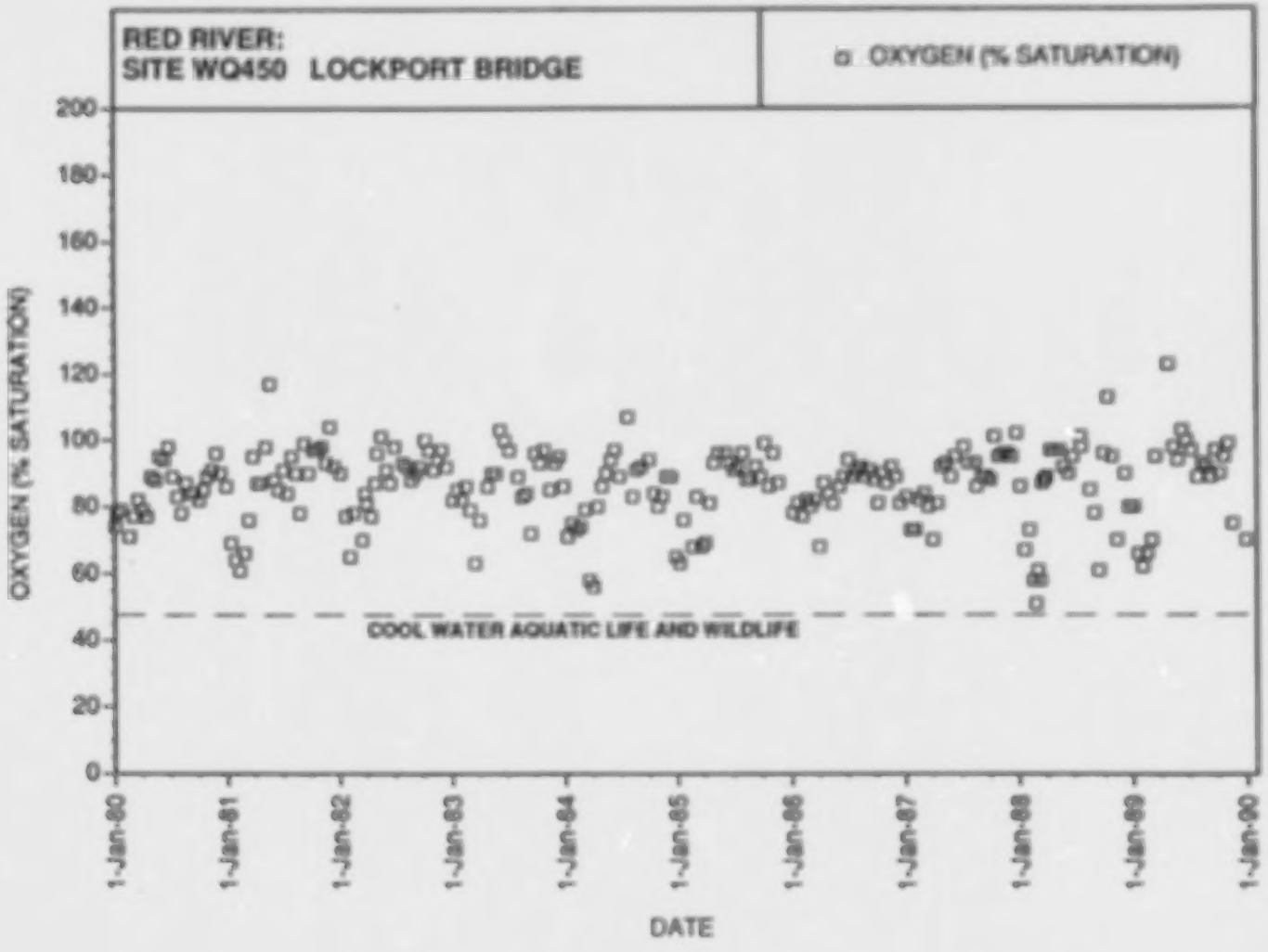


TABLE A50: Summary statistics and exceedence of the percent saturation of oxygen objective for the protection of aquatic life, at site WQ450 at Lockport on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47. (%) [EXCEEDENCE REFERS TO LEVELS BELOW OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	86.2	51.0	123.0	11.1	245	0	0.00%	
1980	84.8	71.0	98.0	7.0	26	0	0.00%	
1981	88.0	61.0	117.0	13.2	25	0	0.00%	
1982	88.3	65.0	101.0	9.2	25	0	0.00%	
1983	87.2	63.0	103.0	9.2	24	0	0.00%	
1984	82.5	56.0	107.0	12.2	24	0	0.00%	
1985	85.4	63.0	99.0	10.3	24	0	0.00%	
1986	85.7	68.0	94.0	6.0	23	0	0.00%	
1987	88.6	70.0	102.0	8.8	25	0	0.00%	
1988	83.4	51.0	113.0	15.9	27	0	0.00%	
1989	88.3	62.0	123.0	14.9	22	0	0.00%	
JAN (80-89)	75.4	62.0	90.0	8.1	19	0	0.00%	
FEB (80-89)	71.2	51.0	86.0	9.0	19	0	0.00%	
MARCH (80-89)	77.5	58.0	95.0	10.3	26	0	0.00%	
APRIL (80-89)	84.6	56.0	123.0	13.2	21	0	0.00%	
MAY (80-89)	93.9	81.0	117.0	7.4	19	0	0.00%	
JUNE (80-89)	93.7	85.0	103.0	5.5	21	0	0.00%	
JULY (80-89)	93.5	83.0	107.0	5.7	19	0	0.00%	
AUG (80-89)	87.0	78.0	93.0	4.9	21	0	0.00%	
SEPT (80-89)	88.4	61.0	99.0	8.6	20	0	0.00%	
OCT (80-89)	92.7	80.0	113.0	7.8	22	0	0.00%	
NOV (80-89)	90.4	70.0	99.0	7.6	20	0	0.00%	
DEC (80-89)	86.9	65.0	104.0	10.0	18	0	0.00%	

FIGURE A93: Percent saturation of oxygen in the Red River, at site WQ142 at Selkirk.

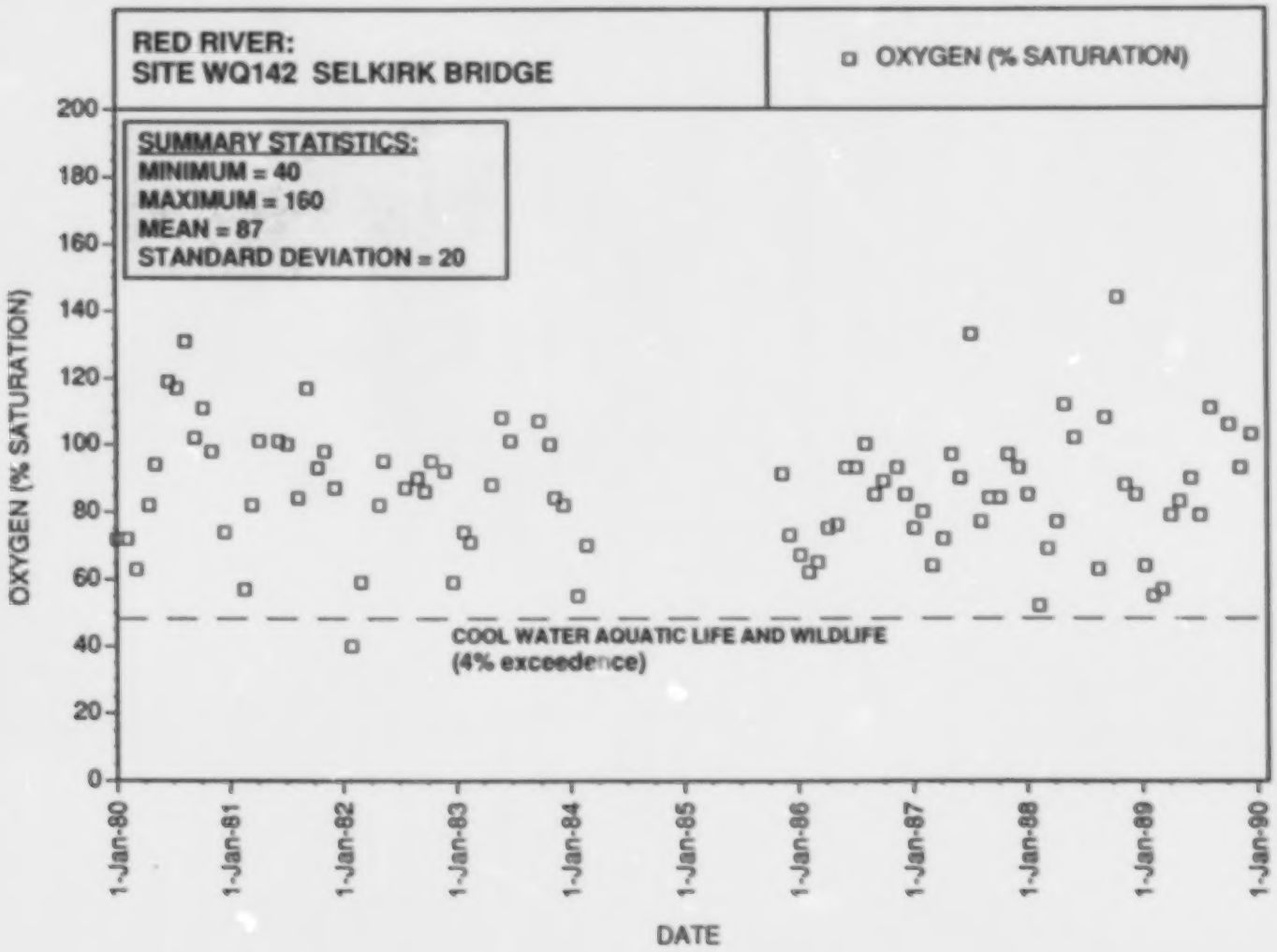


TABLE A60: Trend analysis and paired t-test results on oxygen (% saturation) data.

TREND ANALYSIS RESULTS: % SATURATION OXYGEN. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.00	0.873	N/S	INCREASING	166
WQ451 HEADINGLEY	0.01	0.158	N/S	INCREASING	286
WQ452 WEST PERIMETER	0.00	0.275	N/S	INCREASING	293
WQ453 MAIN STREET BRIDGE	0.02	0.026	*	INCREASING	285
RED RIVER SITES:					
WQ367 SOUTH GATE OF FLOODWAY	0.00	0.954	N/S	INCREASING	120
WQ445 FLOODWAY CONTROL	0.01	0.047	*	INCREASING	305
WQ576 FORT GARY BRIDGE	0.00	0.755	N/S	INCREASING	187
WQ447 NORWOOD BRIDGE	0.01	0.116	N/S	INCREASING	279
WQ448 REDWOOD BRIDGE	0.01	0.055	N/S	INCREASING	281
WQ449 NORTH PERIMETER	0.03	0.005	**	INCREASING	295
WQ450 LOCKPORT BRIDGE	0.02	0.031	*	INCREASING	294
WQ142 SELKIRK	0.02	0.072	N/S	INCREASING	192

PAIRED T-TEST RESULTS: % SATURATION OXYGEN DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (%)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.000	**	-8.05	73
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.000	**	-6.86	85
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.491	N/S	-1.59	75

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

FIGURE A94: Dissolved oxygen concentrations in the Assiniboine River, at site WQ018 at Headingley.

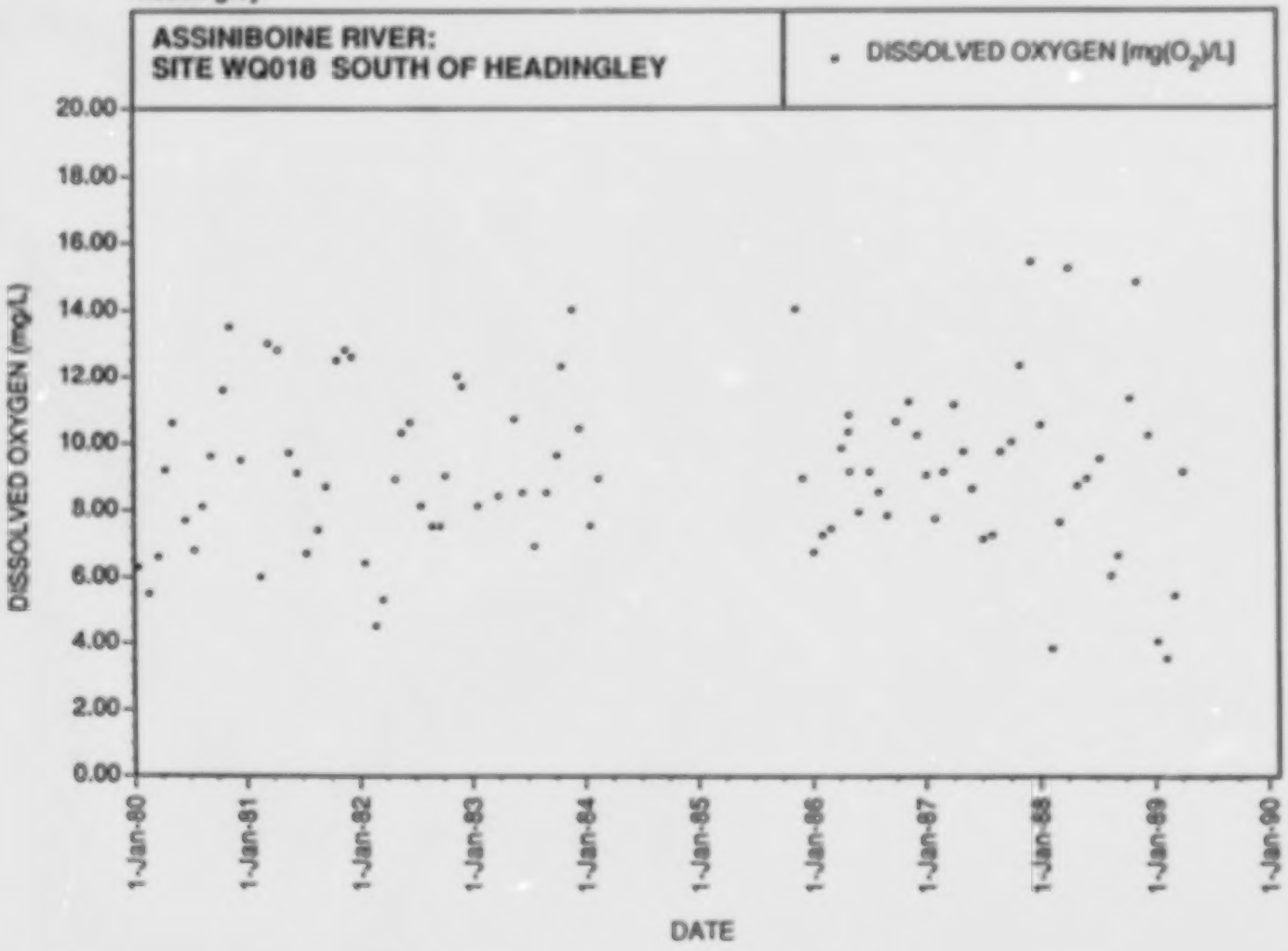


FIGURE A95: Dissolved oxygen concentrations in the Assiniboine River, at site WQ451 at Headingley.

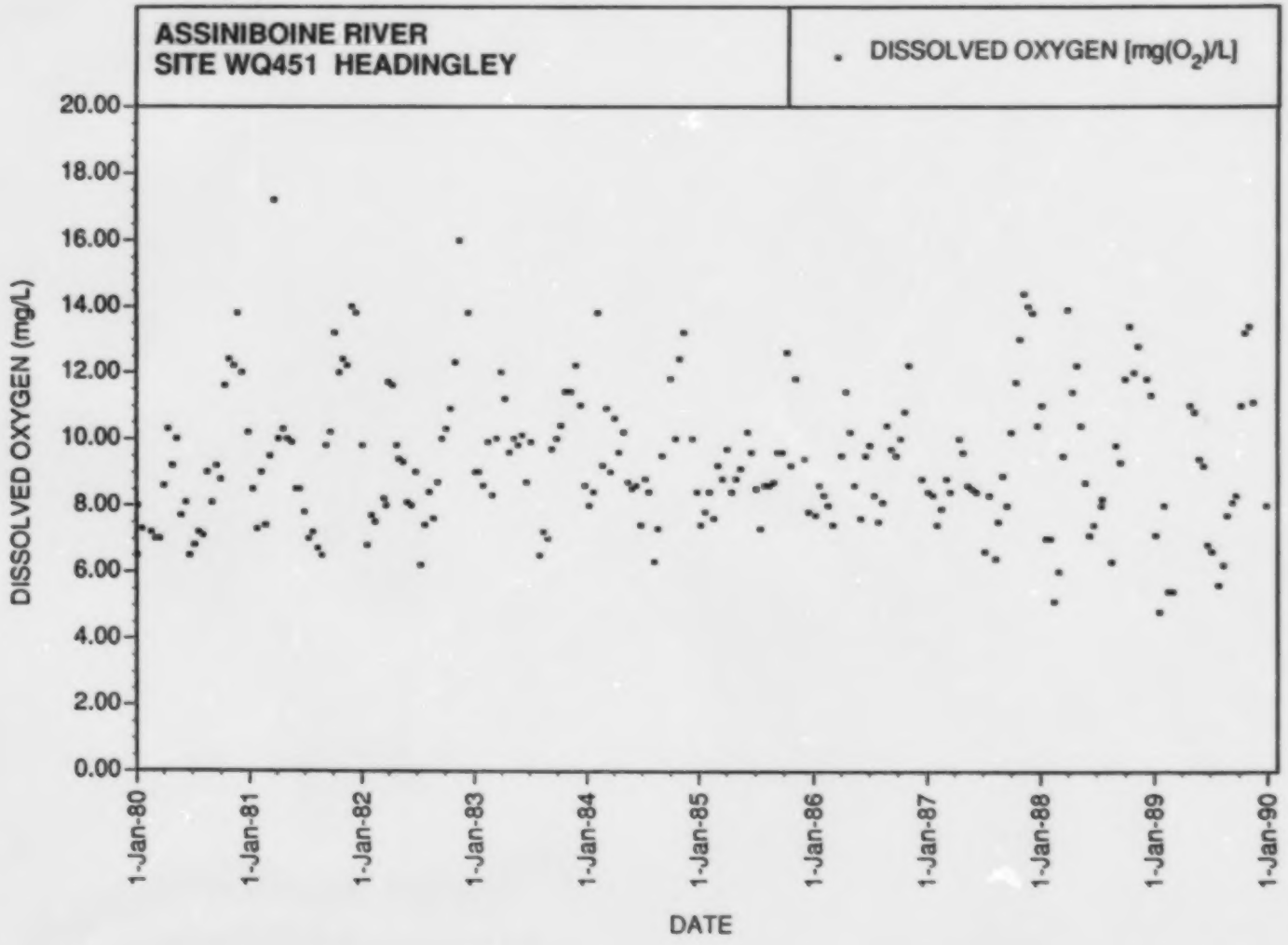


FIGURE A96: Dissolved oxygen concentrations in the Assiniboine River, at site WQ452 at the west perimeter.

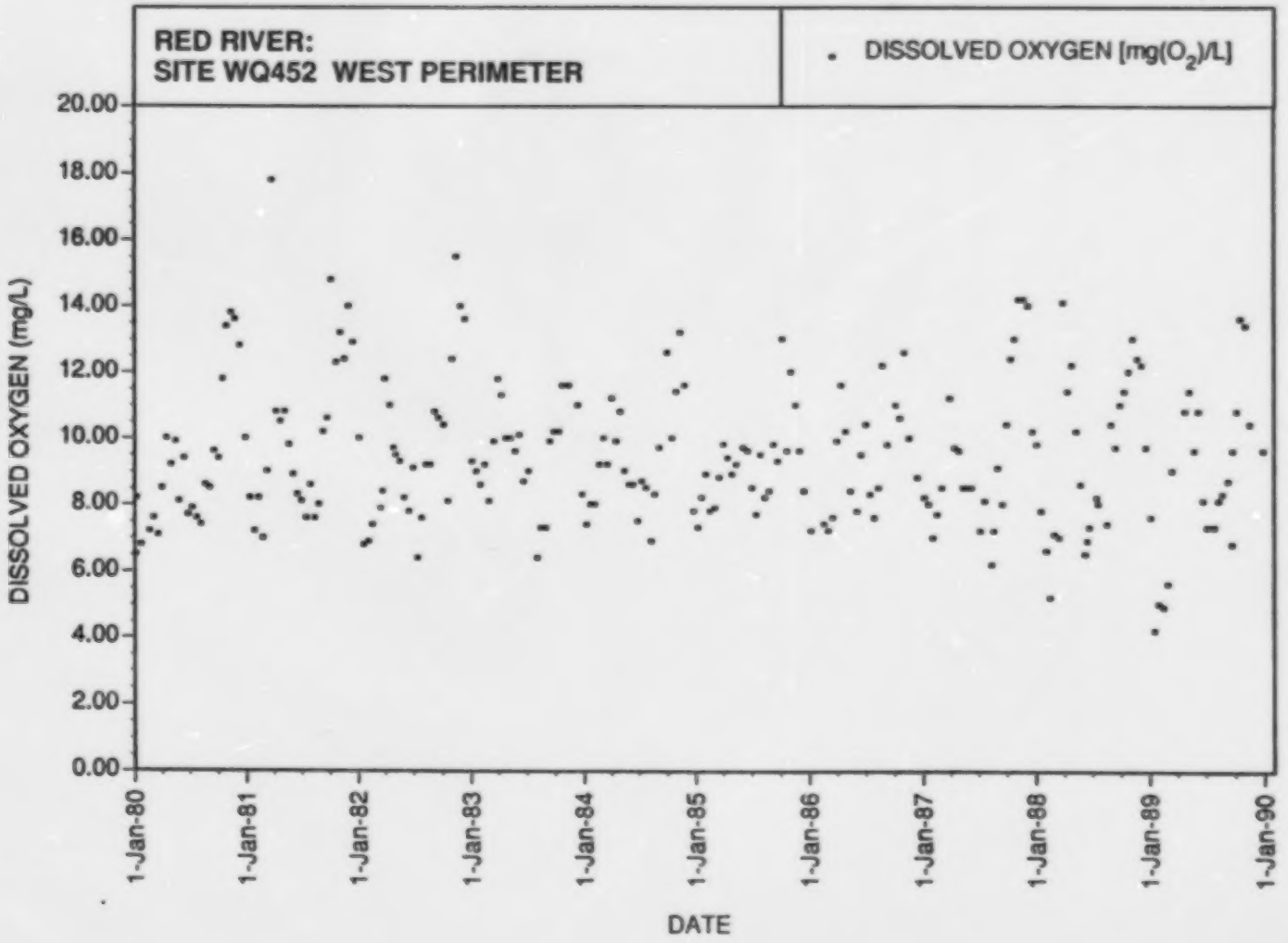


FIGURE A97: Dissolved oxygen concentrations in the Assiniboine River, at site WQ453 at the Main Street Bridge.

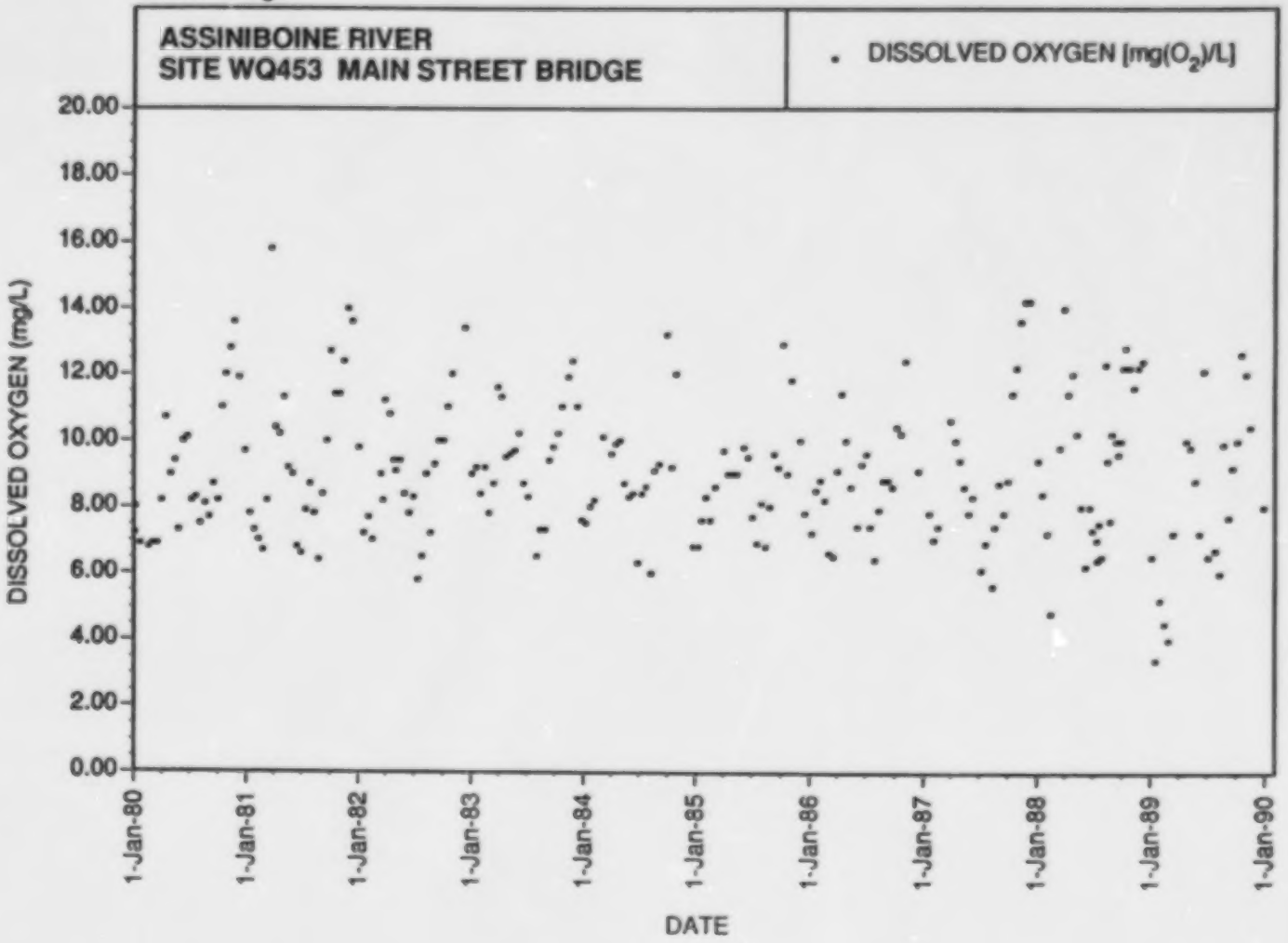


FIGURE A98: Dissolved oxygen concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

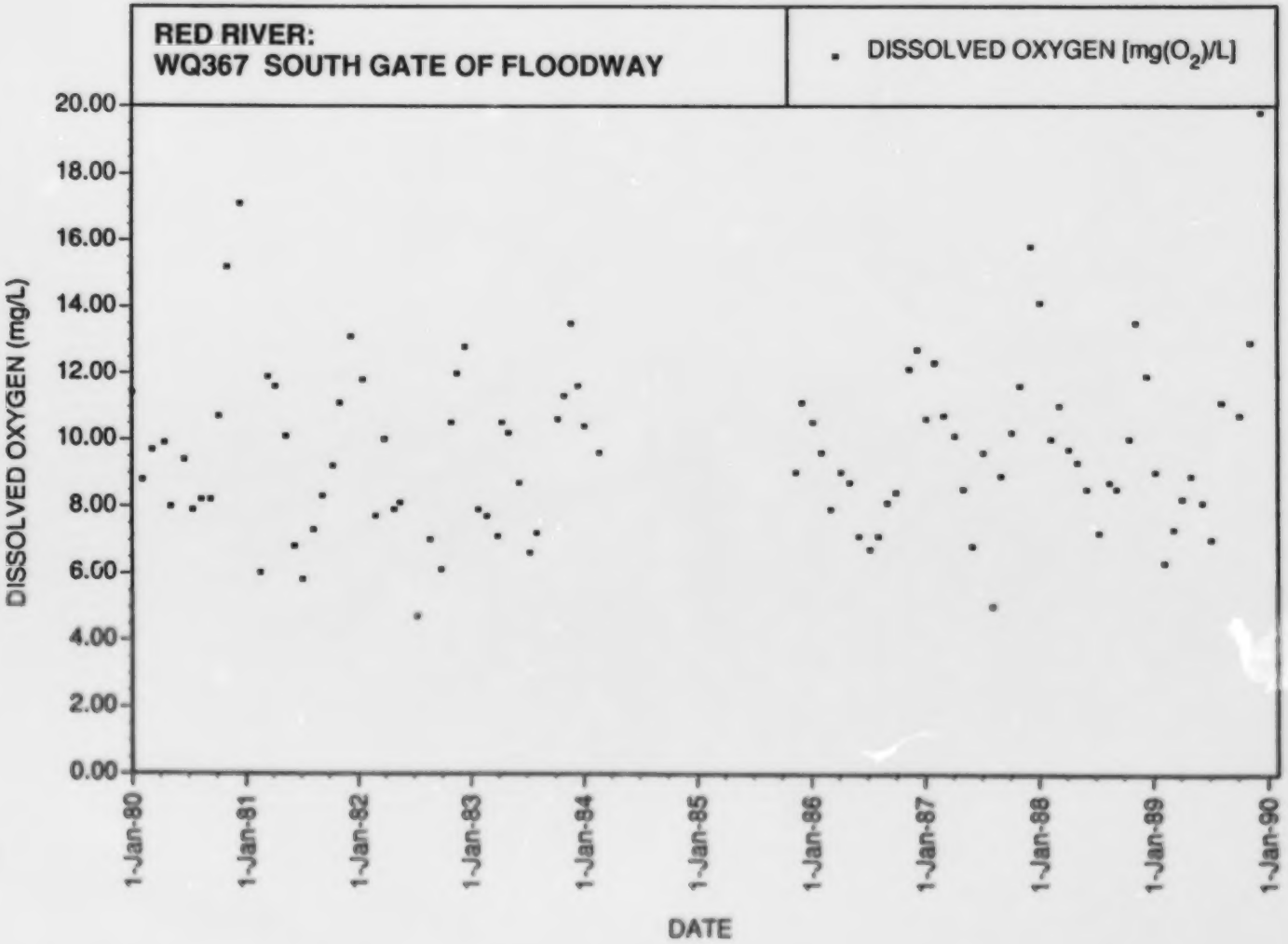


FIGURE A99: Dissolved oxygen concentations in the Red River, at site WQ445 at the south Floodway control.

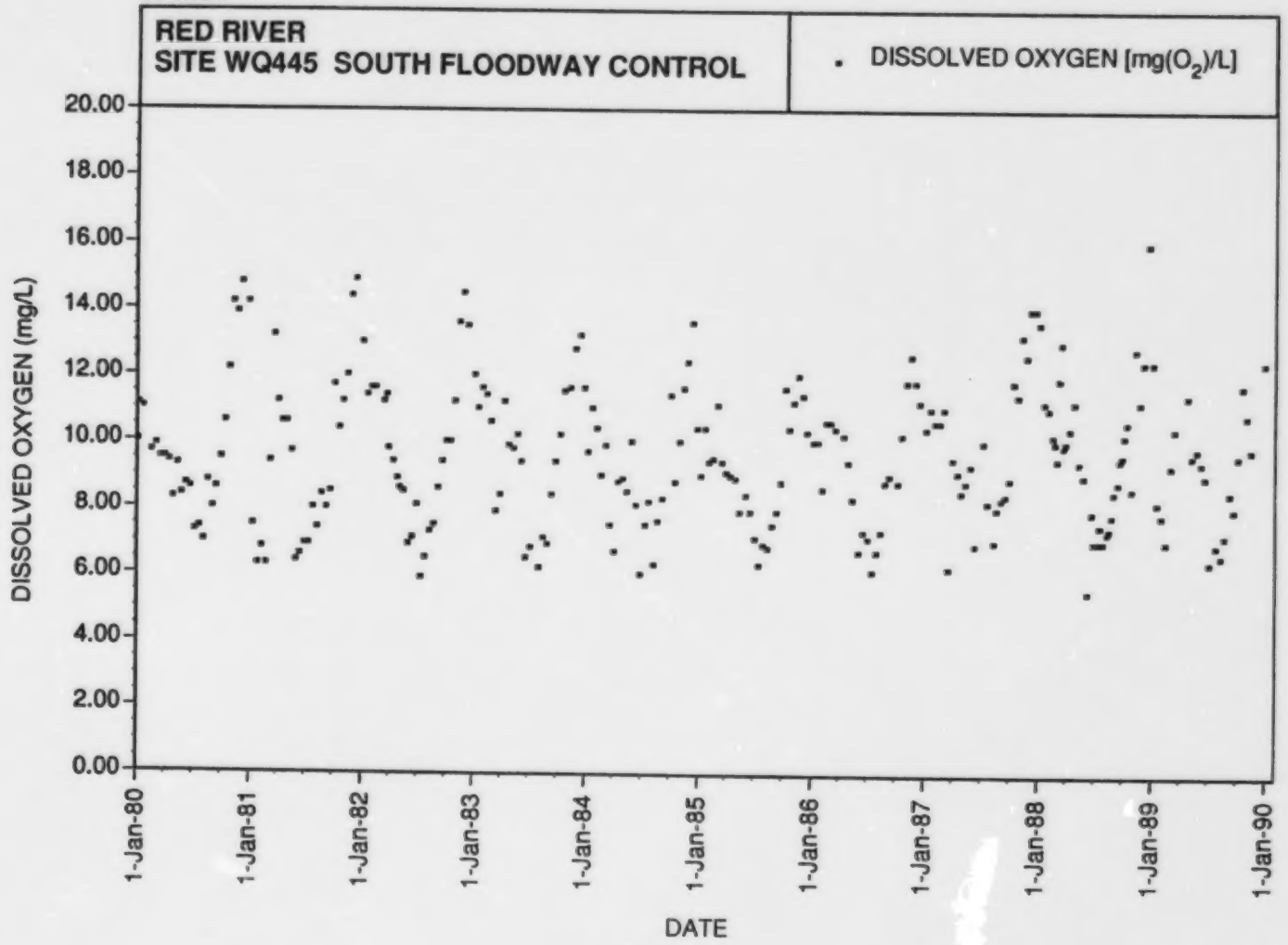


FIGURE A100: Dissolved oxygen concentations in the Red River, at site WQ576 at the Fort Gary Bridge.

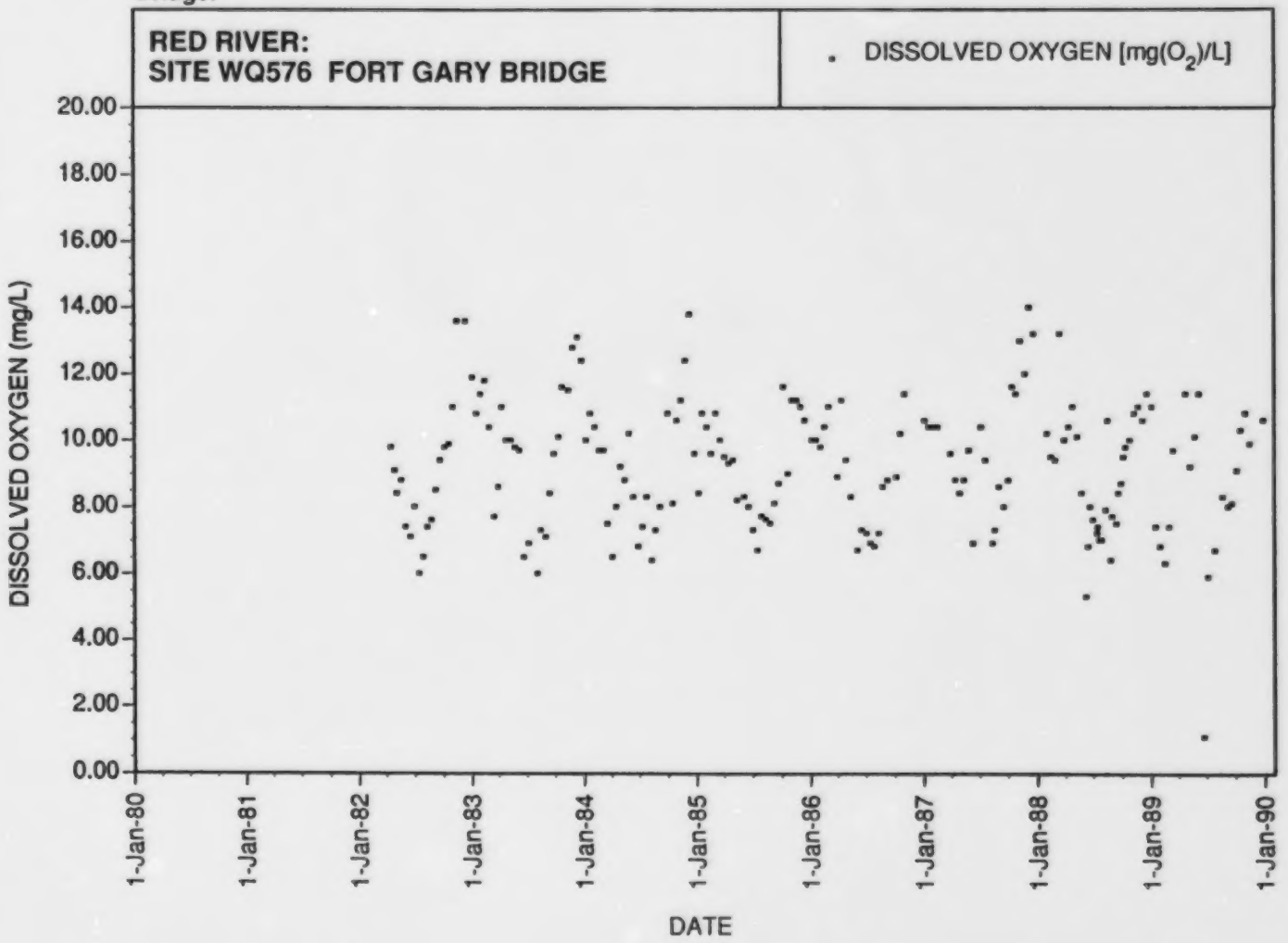


FIGURE A101: Dissolved oxygen concentations in the Red River, at site WQ447 at the Norwood Bridge.

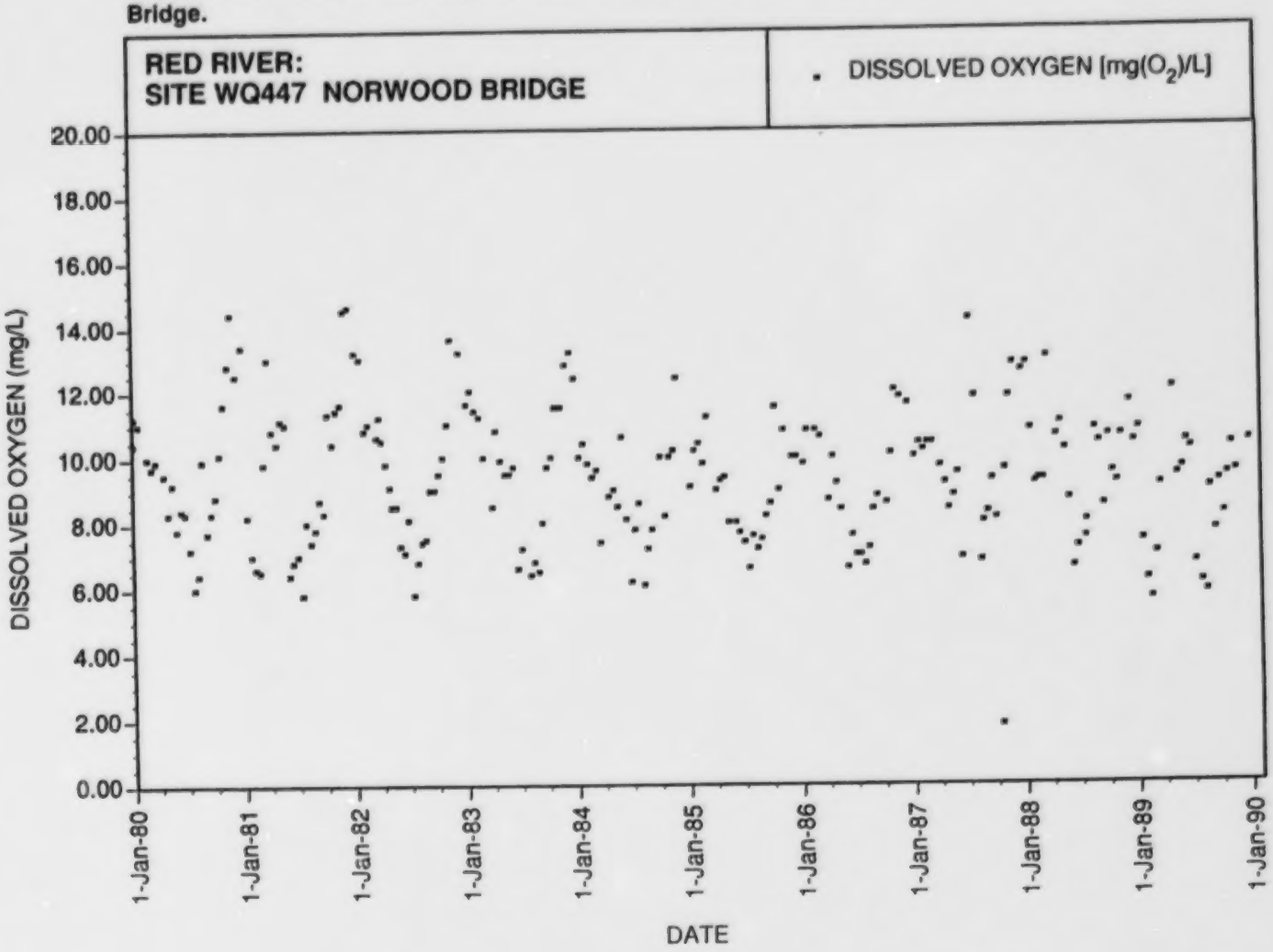


FIGURE A102: Dissolved oxygen concentations in the Red River, at site WQ448 at the Redwood Bridge.

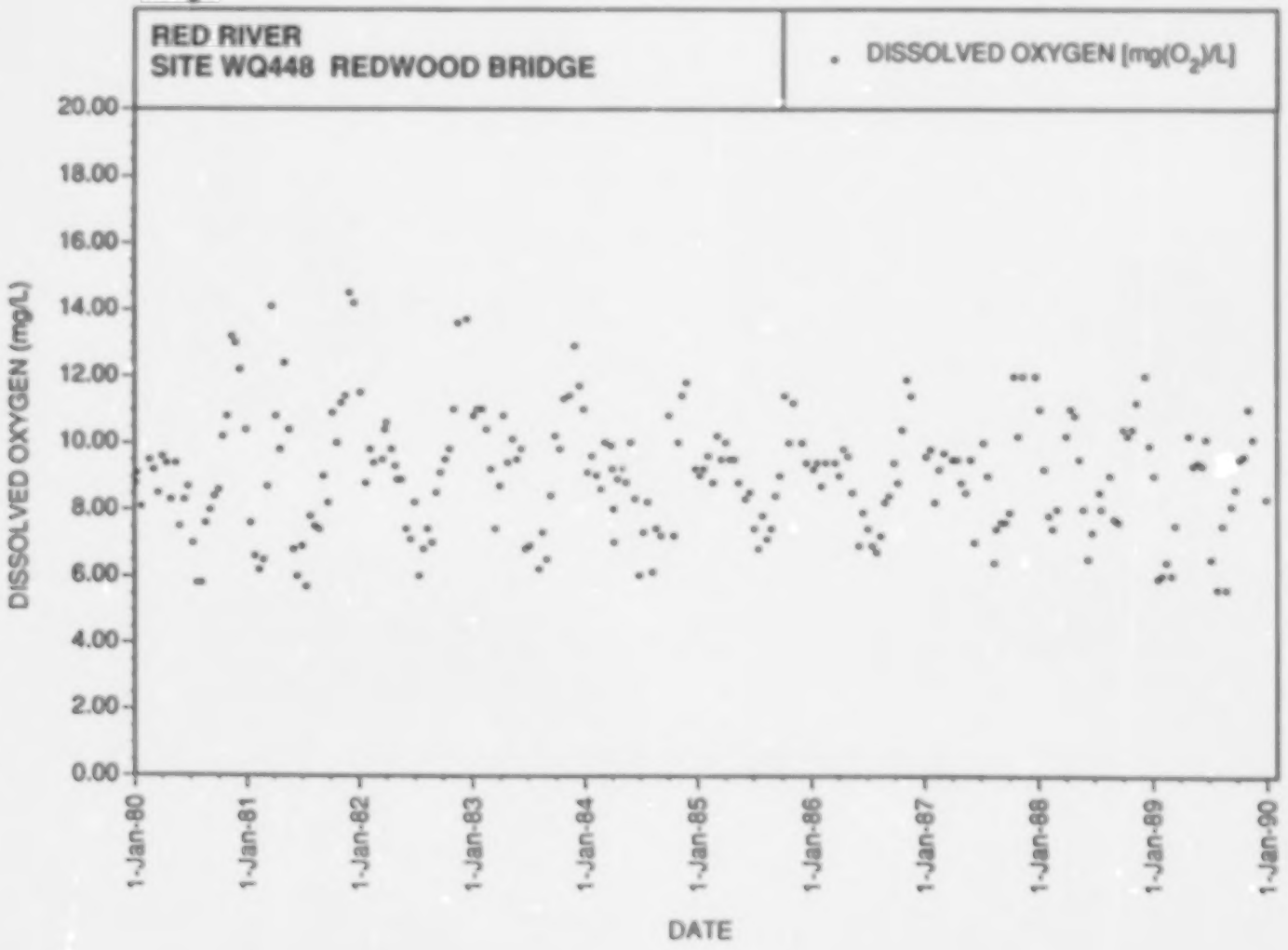


FIGURE A103: Dissolved oxygen concentations in the Red River, at site WQ449 at the north perimeter.

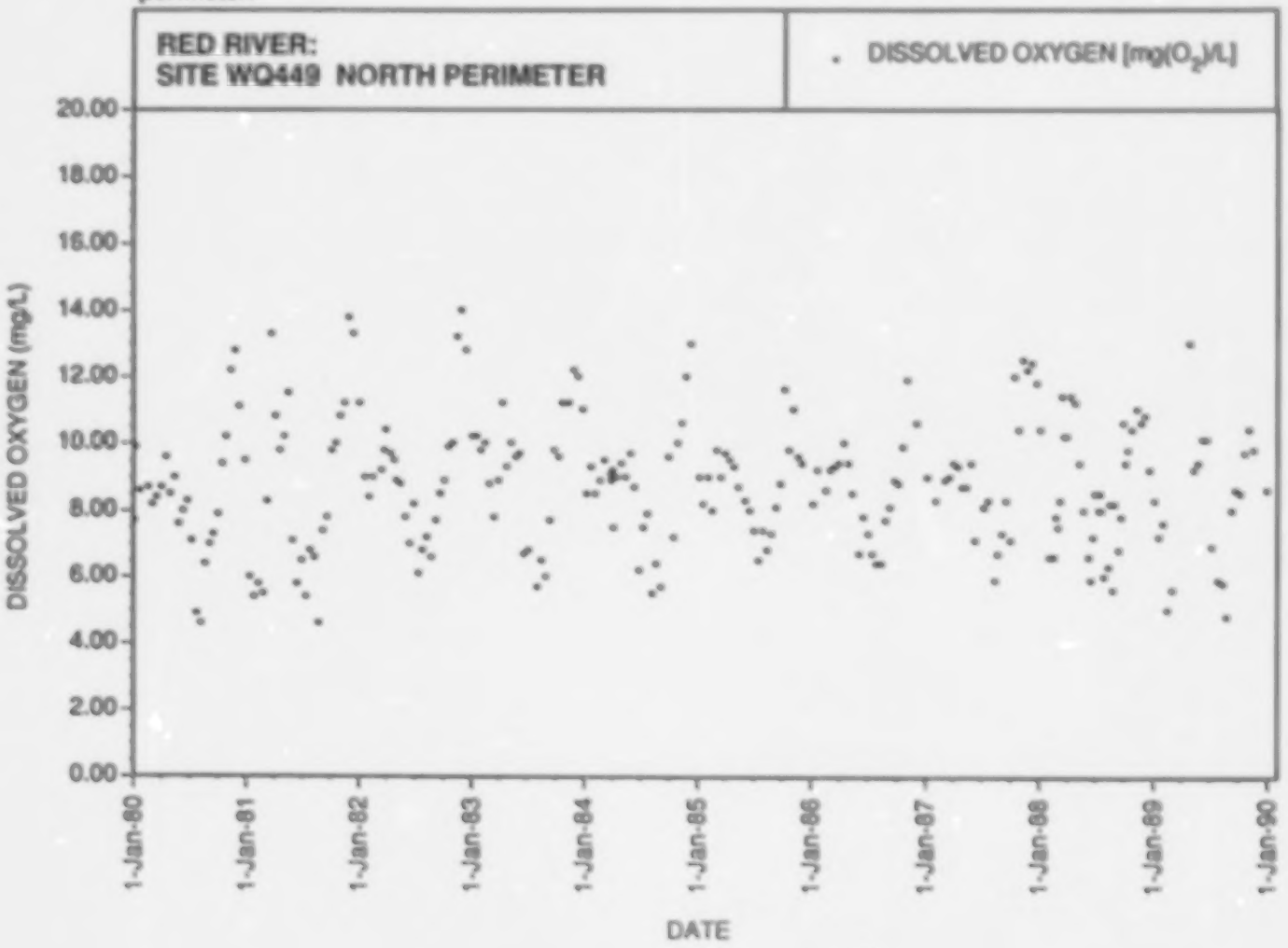


FIGURE A104: Dissolved oxygen concentations in the Red River, at site WQ450 at Lockport.

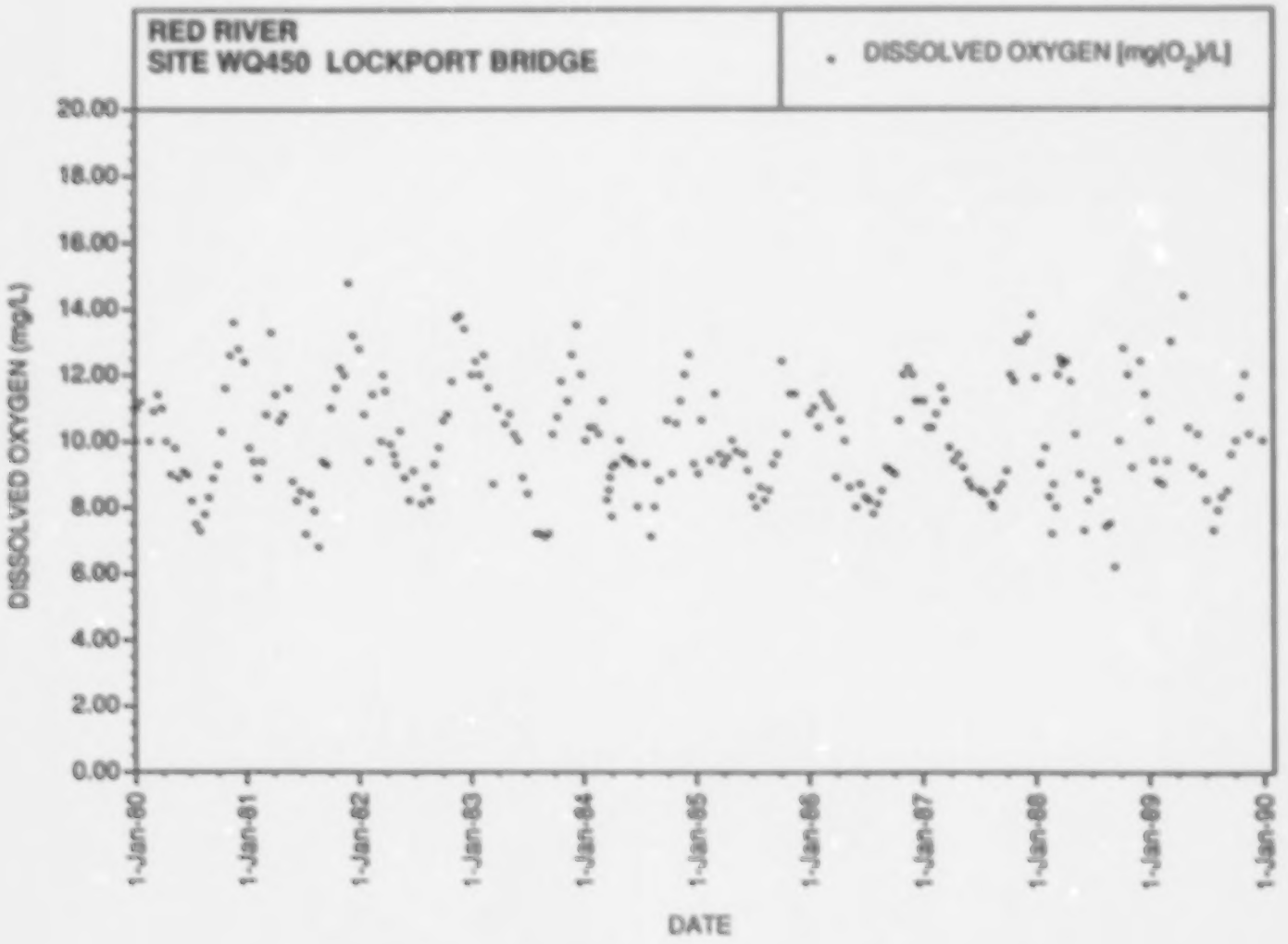


FIGURE A105: Dissolved oxygen concentations in the Red River, at site WQ142 at Selkirk.

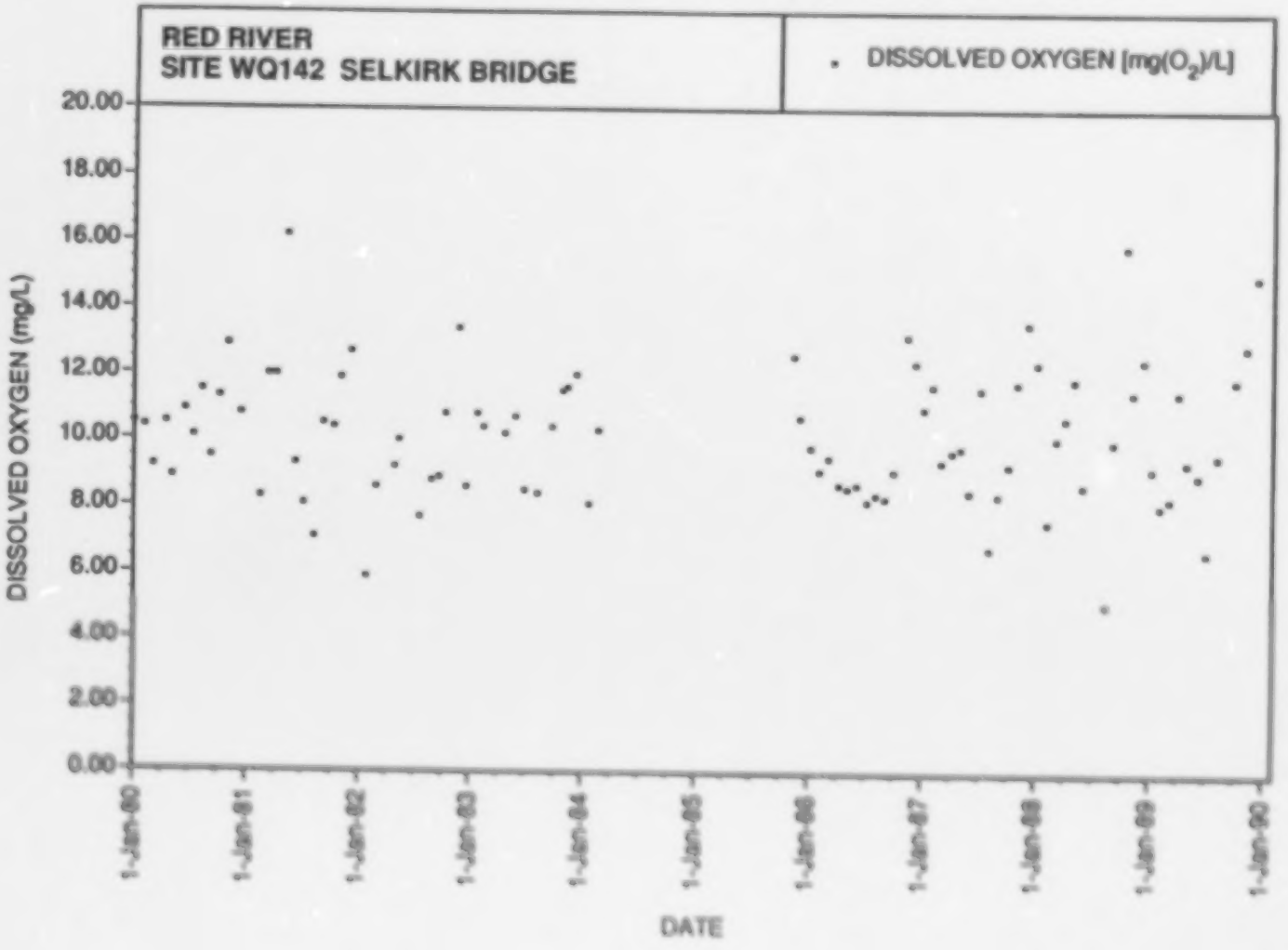


FIGURE A106: pH of the Assiniboine River, at site WQ018 at Headingley.

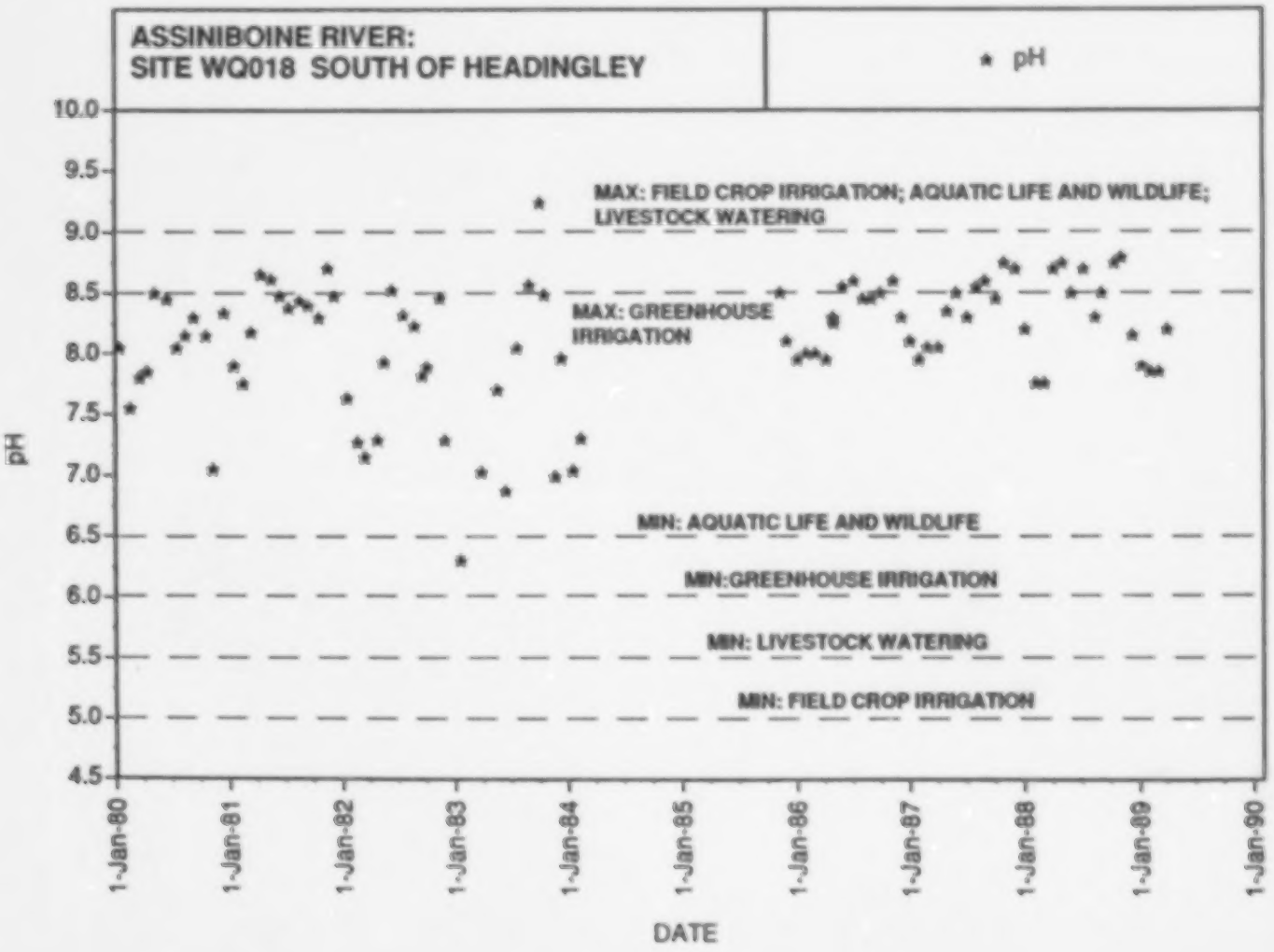


FIGURE A107: pH of the Assiniboine River, at site WQ451 at Headingley.

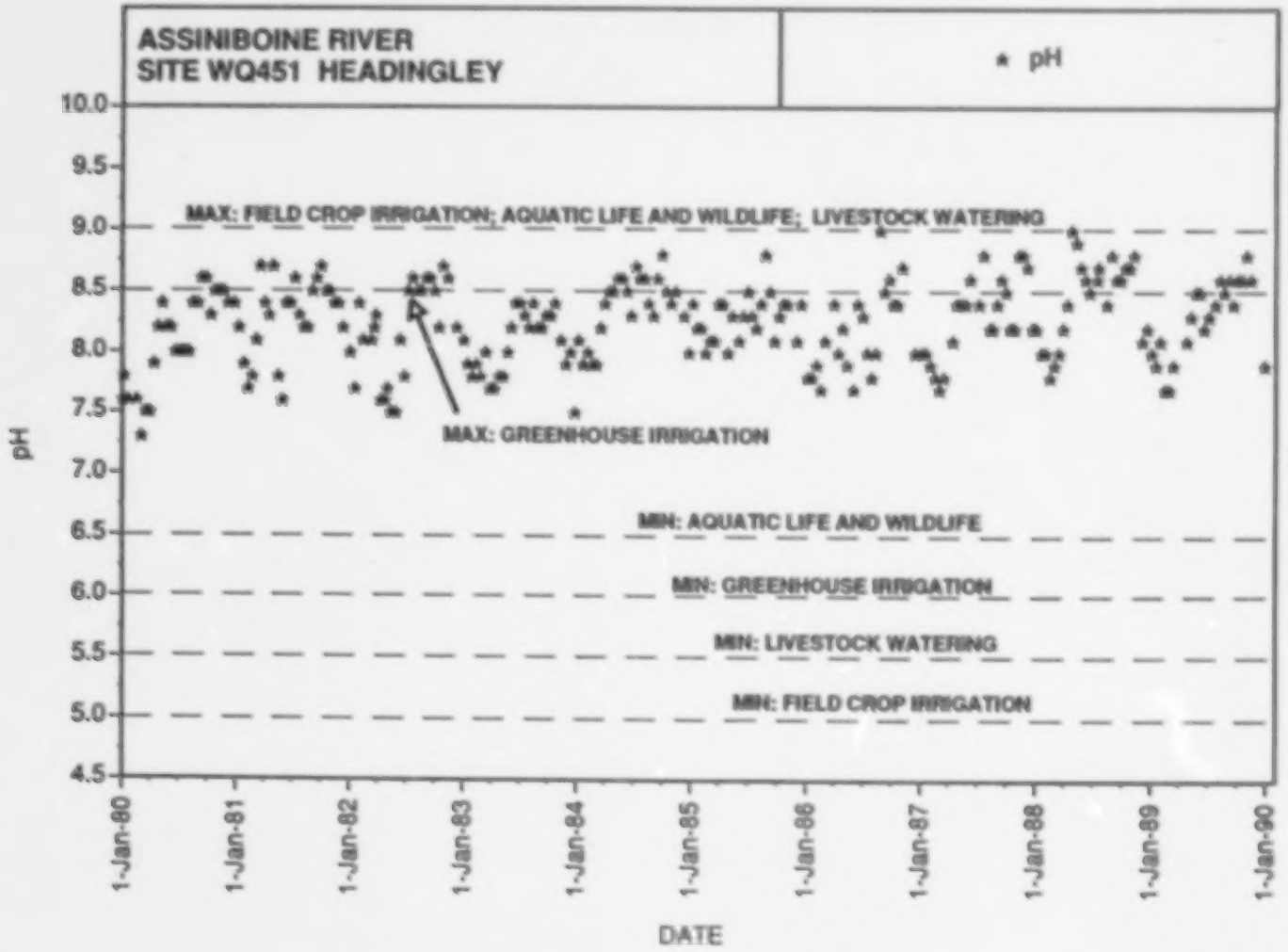


TABLE A61: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ451 at Headingley on the Assiniboine River.

SITE: WQ451 ASSINIBOINE RIVER AT HEADINGLEY
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.2	7.3	9.0	0.34	243	47	19.3%	
1980	8.1	7.3	8.6	0.39	26	2	7.7%	
1981	8.3	7.6	8.7	0.32	25	5	20.0%	
1982	8.2	7.5	8.7	0.39	25	5	20.0%	
1983	8.1	7.5	8.4	0.26	26	0	0.0%	
1984	8.4	7.9	8.8	0.27	25	7	28.0%	
1985	8.3	8.0	8.8	0.19	24	1	4.2%	
1986	8.2	7.7	9.0	0.35	22	3	13.6%	
1987	8.3	7.7	8.8	0.33	24	6	25.0%	
1988	8.4	7.8	9.0	0.34	24	12	50.0%	
1989	8.3	7.7	8.8	0.32	22	6	27.3%	
JAN (80-89)	8.0	7.6	8.4	0.20	22	0	0.0%	
FEB (80-89)	7.9	7.6	8.4	0.20	18	0	0.0%	
MARCH (80-89)	8.0	7.3	8.7	0.30	22	1	4.5%	
APRIL (80-89)	8.2	7.5	9.0	0.36	22	1	4.5%	
MAY (80-89)	8.3	7.5	8.9	0.39	19	5	26.3%	
JUNE (80-89)	8.2	7.5	8.6	0.32	21	2	9.5%	
JULY (80-89)	8.4	7.8	8.8	0.26	22	7	31.8%	
AUG (80-89)	8.4	8.0	9.0	0.26	21	5	23.8%	
SEPT (80-89)	8.5	8.1	8.6	0.15	21	10	47.6%	
OCT (80-89)	8.5	8.2	8.8	0.18	22	7	31.8%	
NOV (80-89)	8.5	7.9	8.8	0.26	16	8	50.0%	
DEC (80-89)	8.2	7.5	8.7	0.27	17	1	5.9%	

FIGURE A108: pH of the Assiniboine River, at site WQ452 at the west perimeter.

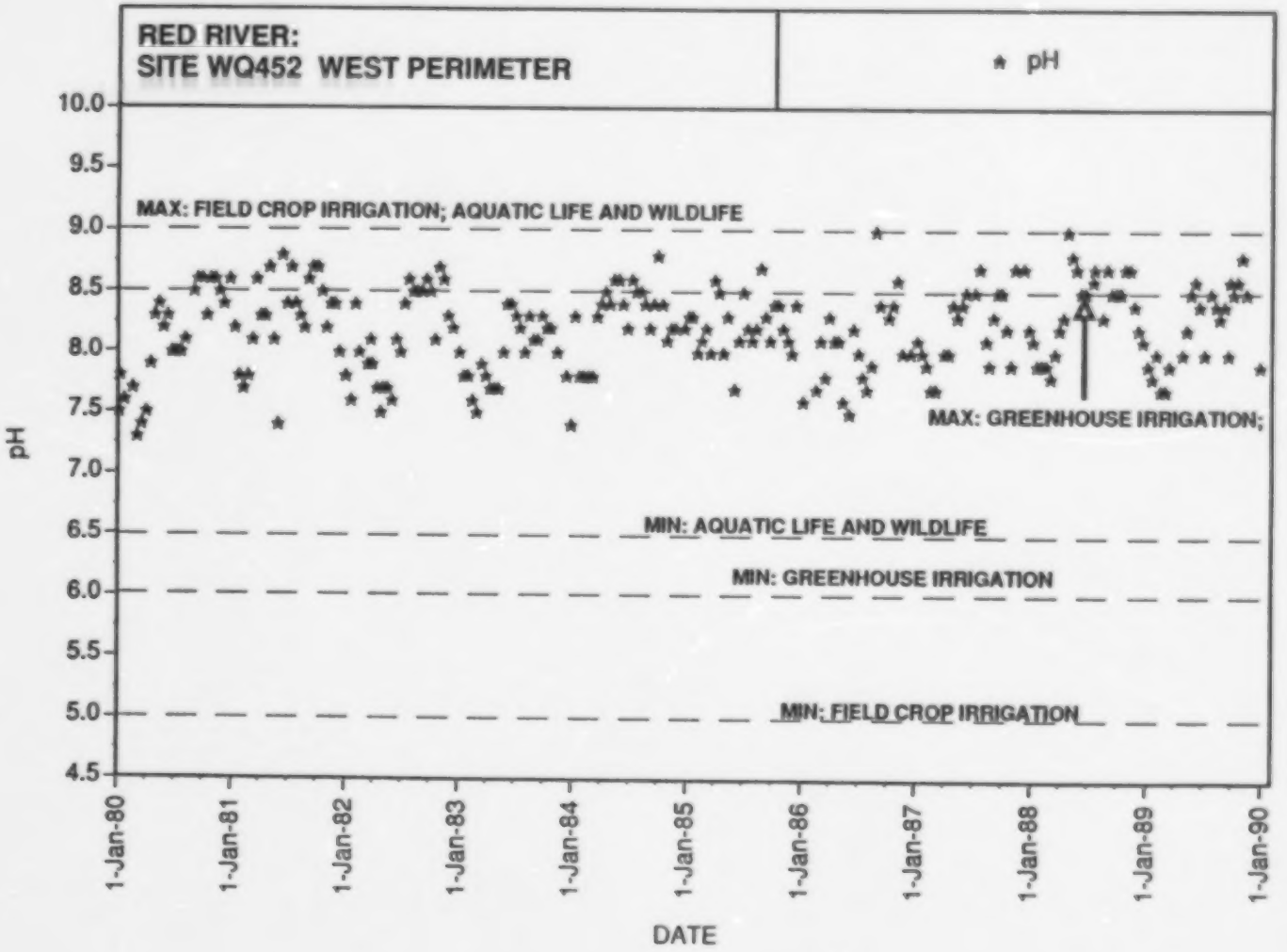


TABLE A62: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ452 at the west perimeter on the Assiniboine River.

SITE: WQ452 ASSINIBOINE RIVER AT THE WEST PERIMETER
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.2	7.3	9.0	0.35	243	39	16.0%	
1980	8.1	7.3	8.6	0.42	25	5	20.0%	
1981	8.3	7.4	8.8	0.35	25	7	28.0%	
1982	8.1	7.5	8.7	0.37	26	4	15.4%	
1983	8.0	7.4	8.4	0.28	25	0	0.0%	
1984	8.3	7.8	8.8	0.27	25	4	16.0%	
1985	8.2	7.7	8.7	0.22	25	2	8.0%	
1986	8.1	7.5	9.0	0.37	21	2	9.5%	
1987	8.2	7.7	8.7	0.31	23	3	13.0%	
1988	8.4	7.8	9.0	0.33	25	8	32.0%	
1989	8.2	7.7	8.8	0.33	23	4	17.4%	
JAN (80-89)	7.9	7.5	8.3	0.24	21	0	0.0%	
FEB (80-89)	7.9	7.6	8.4	0.19	17	0	0.0%	
MARCH (80-89)	7.9	7.3	8.6	0.29	23	1	4.3%	
APRIL (80-89)	8.1	7.5	9.0	0.38	22	2	9.1%	
MAY (80-89)	8.3	7.6	8.8	0.37	19	5	26.3%	
JUNE (80-89)	8.2	7.4	8.8	0.38	21	2	9.5%	
JULY (80-89)	8.3	7.7	8.7	0.30	22	6	27.3%	
AUG (80-89)	8.3	7.9	9.0	0.28	20	3	15.0%	
SEPT (80-89)	8.4	8.0	8.7	0.19	21	5	23.8%	
OCT (80-89)	8.4	7.9	8.8	0.23	22	6	27.3%	
NOV (80-89)	8.4	8.0	8.8	0.25	19	7	36.8%	
DEC (80-89)	8.2	7.4	8.7	0.32	16	2	12.5%	

FIGURE A109: pH of the Assiniboine River, at site WQ453 at the Main Street Bridge.

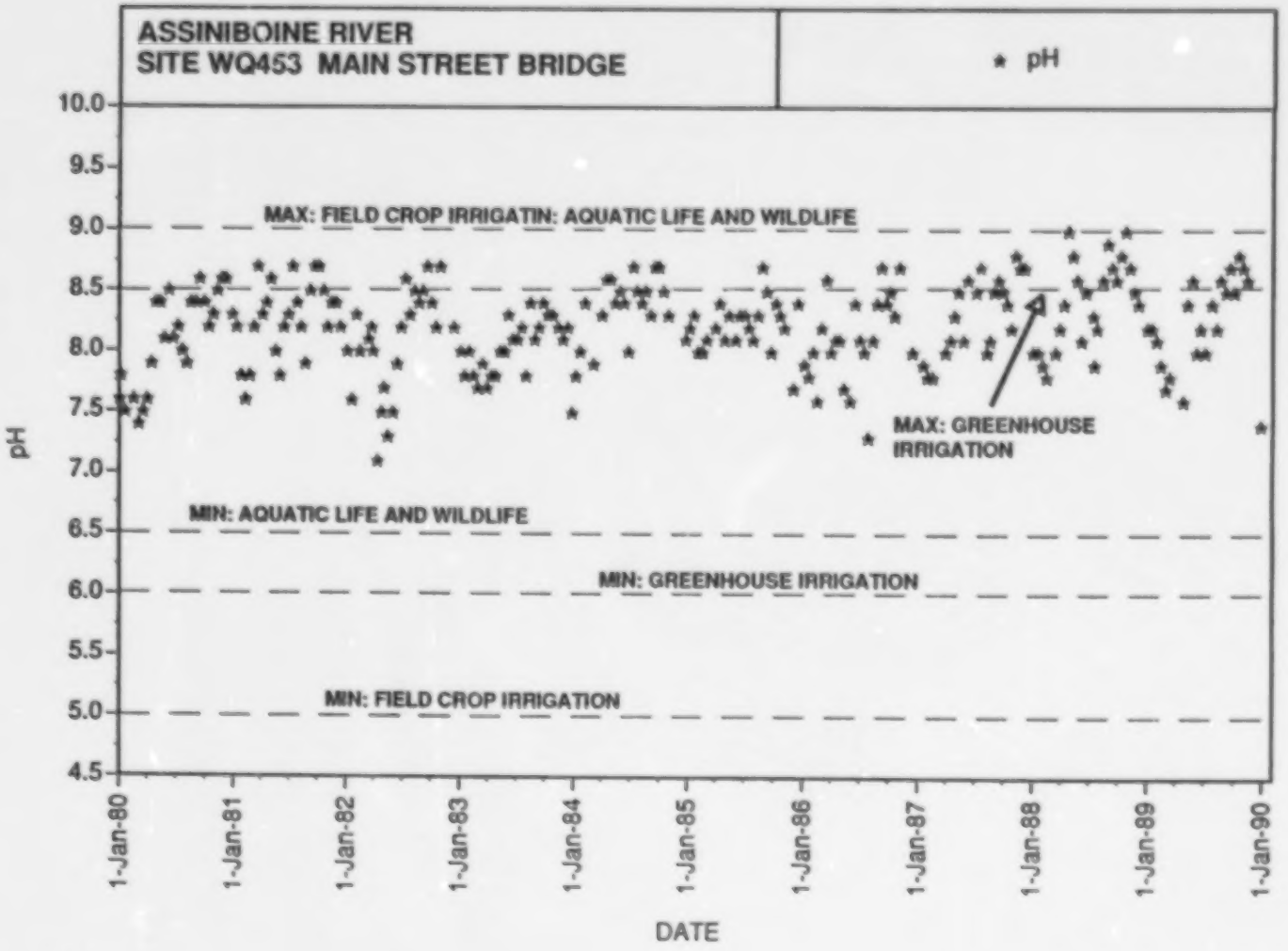


TABLE A63: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ453 at the Main Street Bridge on the Assiniboine River.

SITE: WQ453 ASSINIBOINE RIVER AT THE MAIN STREET BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.2	7.1	9.0	0.35	235	42	17.9%	
1980	8.1	7.4	8.6	0.39	26	3	11.5%	
1981	8.3	7.6	8.7	0.31	25	5	20.0%	
1982	8.1	7.1	8.7	0.44	24	3	12.5%	
1983	8.0	7.5	8.4	0.24	26	0	0.0%	
1984	8.4	7.8	8.7	0.27	21	5	23.8%	
1985	8.2	7.7	8.7	0.20	23	1	4.3%	
1986	8.1	7.3	8.7	0.36	23	3	13.0%	
1987	8.3	7.8	8.8	0.32	21	6	28.6%	
1988	8.4	7.8	9.0	0.37	24	10	41.7%	
1989	8.2	7.4	8.8	0.39	22	6	27.3%	
JAN (80-89)	7.9	7.5	8.3	0.22	21	0	0.0%	
FEB (80-89)	7.9	7.6	8.4	0.22	17	0	0.0%	
MARCH (80-89)	8.0	7.4	8.7	0.33	19	2	10.5%	
APRIL (80-89)	8.1	7.1	9.0	0.42	22	2	9.1%	
MAY (80-89)	8.2	7.3	8.8	0.39	19	5	26.3%	
JUNE (80-89)	8.1	7.5	8.6	0.28	21	1	4.8%	
JULY (80-89)	8.2	7.3	8.7	0.32	23	4	17.4%	
AUG (80-89)	8.3	7.8	8.9	0.29	21	4	19.0%	
SEPT (80-89)	8.5	8.0	8.7	0.18	21	9	42.9%	
OCT (80-89)	8.5	8.2	9.0	0.22	22	5	22.7%	
NOV (80-89)	8.5	8.1	8.8	0.23	15	8	53.3%	
DEC (80-89)	8.2	7.4	8.7	0.39	14	2	14.3%	

FIGURE A110: pH of the Red River, at site WQ367 at the south gate of the Floodway.

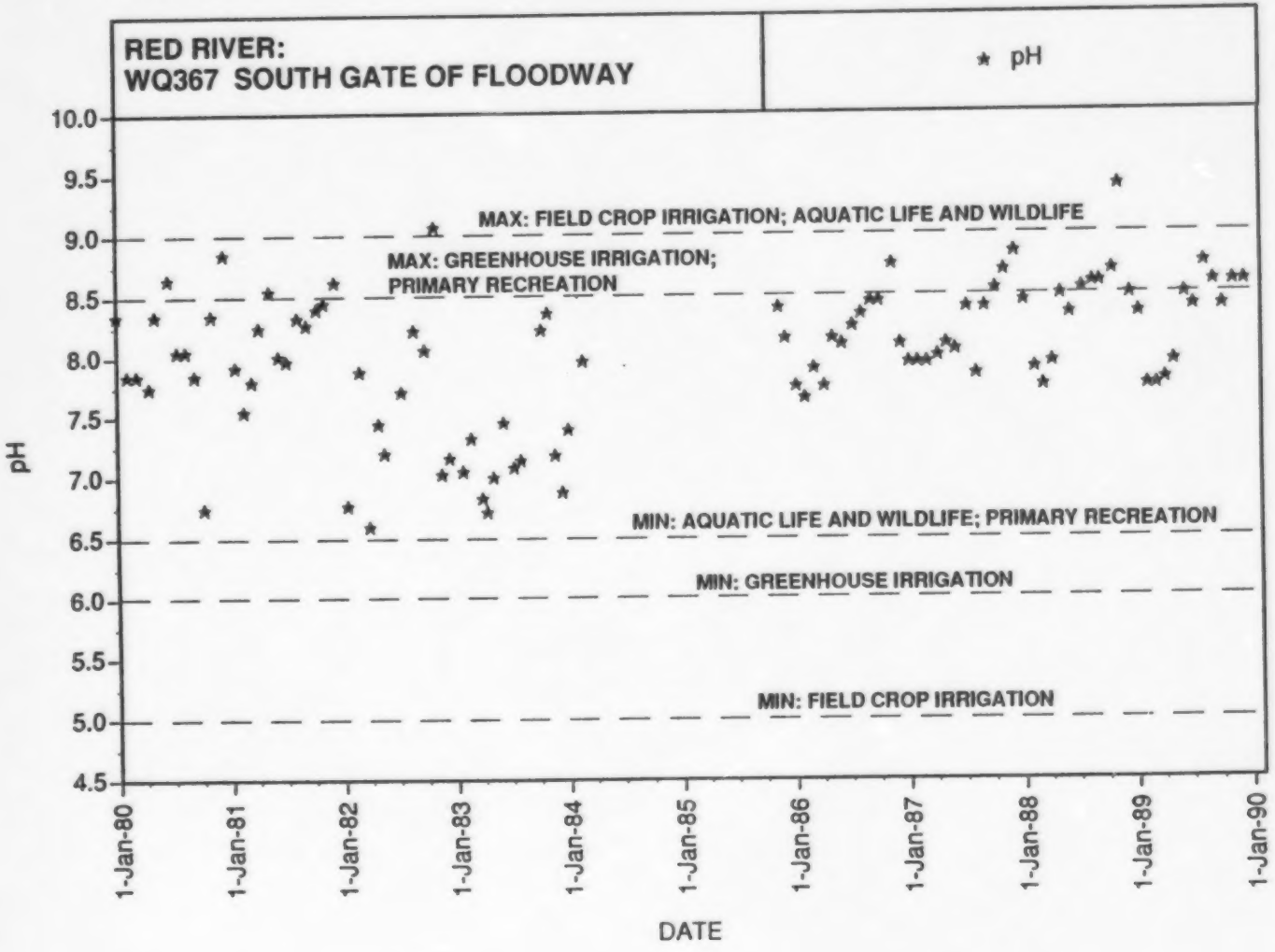


FIGURE A111: pH of the Red River, at site WQ445 at the south Floodway control.

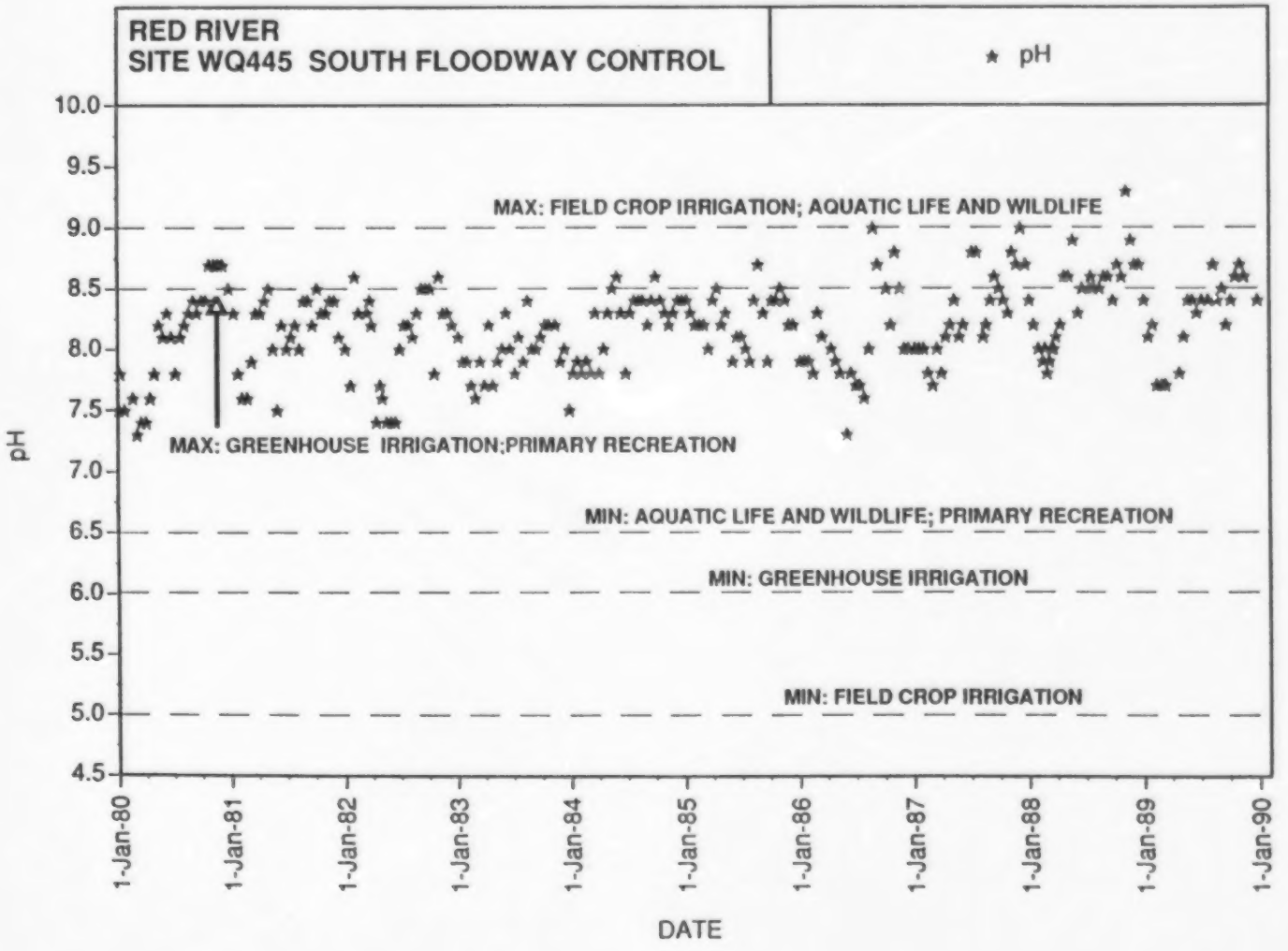


TABLE A64: Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.2	7.3	9.3	0.35	253	35	13.8%	
1980	8.1	7.3	8.7	0.45	26	4	15.4%	
1981	8.1	7.5	8.5	0.29	25	0	0.0%	
1982	8.1	7.4	8.6	0.40	26	2	7.7%	
1983	8.0	7.5	8.4	0.22	26	0	0.0%	
1984	8.2	7.8	8.6	0.27	26	2	7.7%	
1985	8.2	7.9	8.7	0.21	25	1	4.0%	
1986	8.1	7.3	9.0	0.41	23	3	13.0%	
1987	8.3	7.7	9.0	0.36	25	7	28.0%	
1988	8.4	7.8	9.3	0.36	29	12	41.4%	
1989	8.3	7.7	8.7	0.31	22	4	18.2%	
JAN (80-89)	8.0	7.5	8.4	0.27	21	0	0.0%	
FEB (80-89)	7.9	7.6	8.6	0.26	20	1	5.0%	
MARCH (80-89)	7.9	7.3	8.4	0.29	26	0	0.0%	
APRIL (80-89)	8.0	7.4	8.6	0.34	21	1	4.8%	
MAY (80-89)	8.2	7.4	8.9	0.37	19	3	15.8%	
JUNE (80-89)	8.0	7.3	8.5	0.35	21	0	0.0%	
JULY (80-89)	8.2	7.6	8.8	0.34	23	3	13.0%	
AUG (80-89)	8.3	7.9	9.0	0.27	21	4	19.0%	
SEPT (80-89)	8.4	7.9	8.7	0.21	20	3	15.0%	
OCT (80-89)	8.4	7.8	8.7	0.20	22	5	22.7%	
NOV (80-89)	8.5	7.9	9.3	0.31	21	10	47.6%	
DEC (80-89)	8.3	7.5	9.0	0.36	18	5	27.8%	

TABLE A65: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ445 at the south Floodway control on the Red River.

SITE: WQ445 RED RIVER AT THE SOUTH FLOODWAY CONTROL
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.2	7.3	9.3	0.35	253	35	13.8%	
1980	8.1	7.3	8.7	0.45	26	4	15.4%	
1981	8.1	7.5	8.5	0.29	25	0	0.0%	
1982	8.1	7.4	8.6	0.40	26	2	7.7%	
1983	8.0	7.5	8.4	0.22	26	0	0.0%	
1984	8.2	7.8	8.6	0.27	26	2	7.7%	
1985	8.2	7.9	8.7	0.21	25	1	4.0%	
1986	8.1	7.3	9.0	0.41	23	3	13.0%	
1987	8.3	7.7	9.0	0.36	25	7	28.0%	
1988	8.4	7.8	9.3	0.36	29	12	41.4%	
1989	8.3	7.7	8.7	0.31	22	4	18.2%	
JAN (80-89)	8.0	7.5	8.4	0.27	21	0	0.0%	
FEB (80-89)	7.9	7.6	8.6	0.26	20	1	5.0%	
MARCH (80-89)	7.9	7.3	8.4	0.29	26	0	0.0%	
APRIL (80-89)	8.0	7.4	8.6	0.34	21	1	4.8%	
MAY (80-89)	8.2	7.4	8.9	0.37	19	3	15.8%	
JUNE (80-89)	8.0	7.3	8.5	0.35	21	0	0.0%	
JULY (80-89)	8.2	7.6	8.8	0.34	23	3	13.0%	
AUG (80-89)	8.3	7.9	9.0	0.27	21	4	19.0%	
SEPT (80-89)	8.4	7.9	8.7	0.21	20	3	15.0%	
OCT (80-89)	8.4	7.8	8.7	0.20	22	5	22.7%	
NOV (80-89)	8.5	7.9	9.3	0.31	21	10	47.6%	
DEC (80-89)	8.3	7.5	9.0	0.36	18	5	27.8%	

FIGURE A112: pH of the Red River, at site WQ576 at the Fort Gary Bridge.

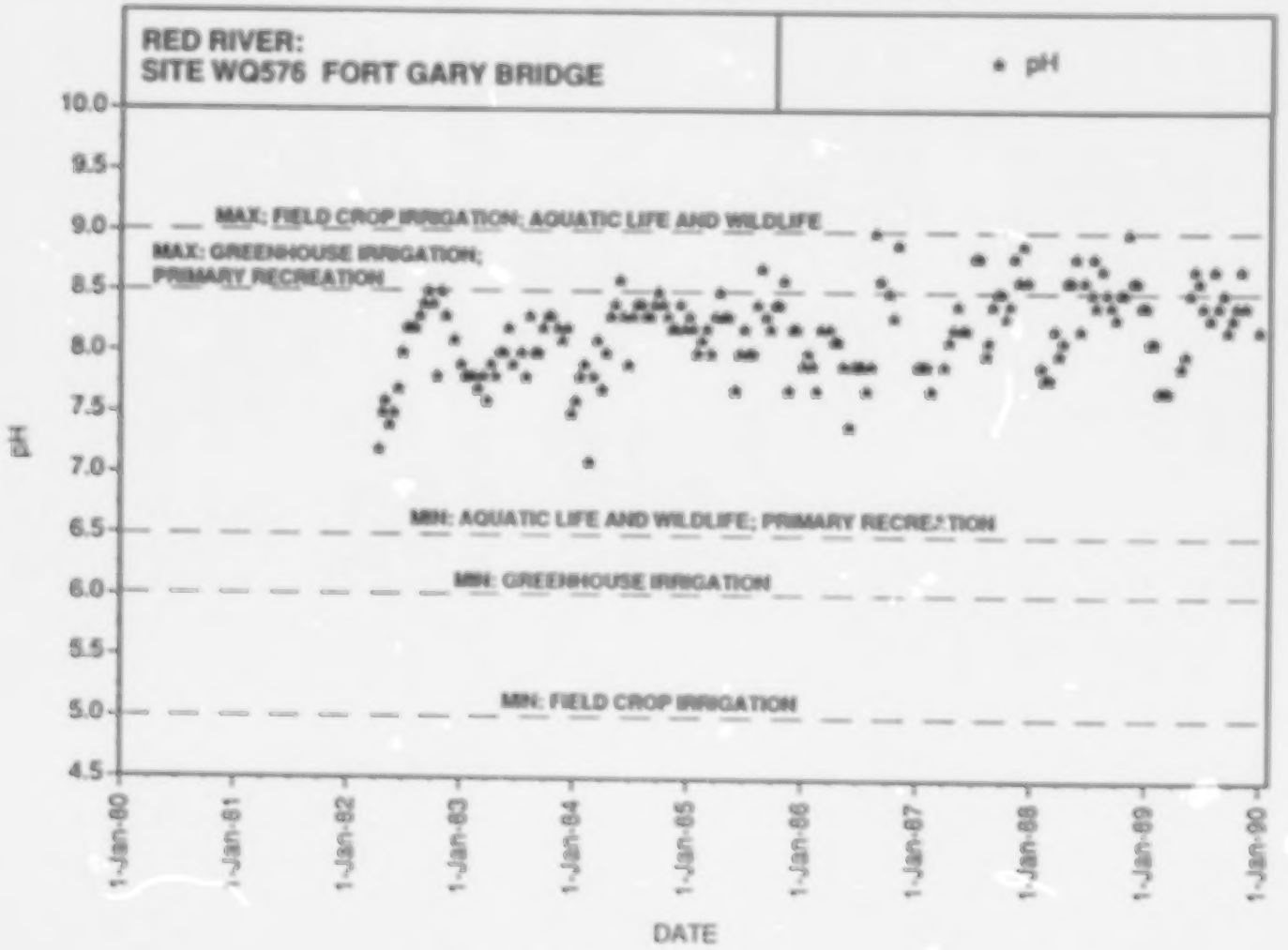


TABLE A66: Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ576 at the Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	8.2	7.1	9.0	0.35	184	25	14%	
1980								
1981								
1982	8.0	7.2	8.5	0.40	19	0	0%	
1983	8.0	7.5	8.3	0.22	25	0	0%	
1984	8.1	7.1	8.6	0.34	26	1	4%	
1985	8.2	7.7	8.7	0.24	25	2	8%	
1986	8.1	7.4	9.0	0.40	20	3	15%	
1987	8.3	7.7	8.9	0.34	23	6	26%	
1988	8.4	7.8	9.0	0.32	24	9	38%	
1989	8.3	7.7	8.7	0.32	22	4	18%	
JAN (82-89)	8.0	7.6	8.4	0.22	13	0	0%	
FEB (82-89)	7.8	7.1	8.1	0.24	13	0	0%	
MARCH (82-89)	7.9	7.6	8.2	0.21	14	0	0%	
APRIL (82-89)	8.0	7.2	8.6	0.35	17	1	6%	
MAY (82-89)	8.2	7.4	8.8	0.39	15	3	20%	
JUNE (82-89)	8.1	7.4	9.7	0.38	16	3	19%	
JULY (82-89)	8.2	7.7	8.8	0.33	19	3	16%	
AUG (82-89)	8.3	7.8	9.0	0.32	17	4	24%	
SEPT (82-89)	8.4	8.0	8.6	0.15	16	1	6%	
OCT (82-89)	8.4	7.8	8.5	0.16	17	0	0%	
NOV (82-89)	8.5	7.7	9.0	0.34	15	7	47%	
DEC (82-89)	8.3	7.5	8.9	0.34	12	3	25%	

TABLE A67: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ576 at the Fort Gary Bridge on the Red River.

SITE: WQ576 RED RIVER AT THE FORT GARY BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1982-1989	8.2	7.1	9.0	0.35	184	25	14.%	
1980								
1981								
1982	8.0	7.2	8.5	0.40	19	0	0%	
1983	8.0	7.5	8.3	0.22	25	0	0%	
1984	8.1	7.1	8.6	0.34	26	1	4%	
1985	8.2	7.7	8.7	0.24	25	2	8%	
1986	8.1	7.4	9.0	0.40	20	3	15%	
1987	8.3	7.7	8.9	0.34	23	6	26%	
1988	8.4	7.8	9.0	0.32	24	9	38%	
1989	8.3	7.7	8.7	0.32	22	4	18%	
JAN (82-89)	8.0	7.6	8.4	0.22	13	0	0%	
FEB (82-89)	7.8	7.1	8.1	0.24	13	0	0%	
MARCH (82-89)	7.9	7.6	8.2	0.21	14	0	0%	
APRIL (82-89)	8.0	7.2	8.6	0.35	17	1	6%	
MAY (82-89)	8.2	7.4	8.8	0.39	15	3	20%	
JUNE (82-89)	8.1	7.4	8.7	0.38	16	3	19%	
JULY (82-89)	8.2	7.7	8.8	0.33	19	3	16%	
AUG (82-89)	8.3	7.8	9.0	0.32	17	4	24%	
SEPT (82-89)	8.4	8.0	8.8	0.15	16	1	6%	
OCT (82-89)	8.4	7.8	8.5	0.18	17	0	0%	
NOV (82-89)	8.5	7.7	9.0	0.34	15	7	47%	
DEC (82-89)	8.3	7.5	8.9	0.34	12	3	25%	

FIGURE A113: pH of the Red River, at site WQ447 at the Norwood Bridge.

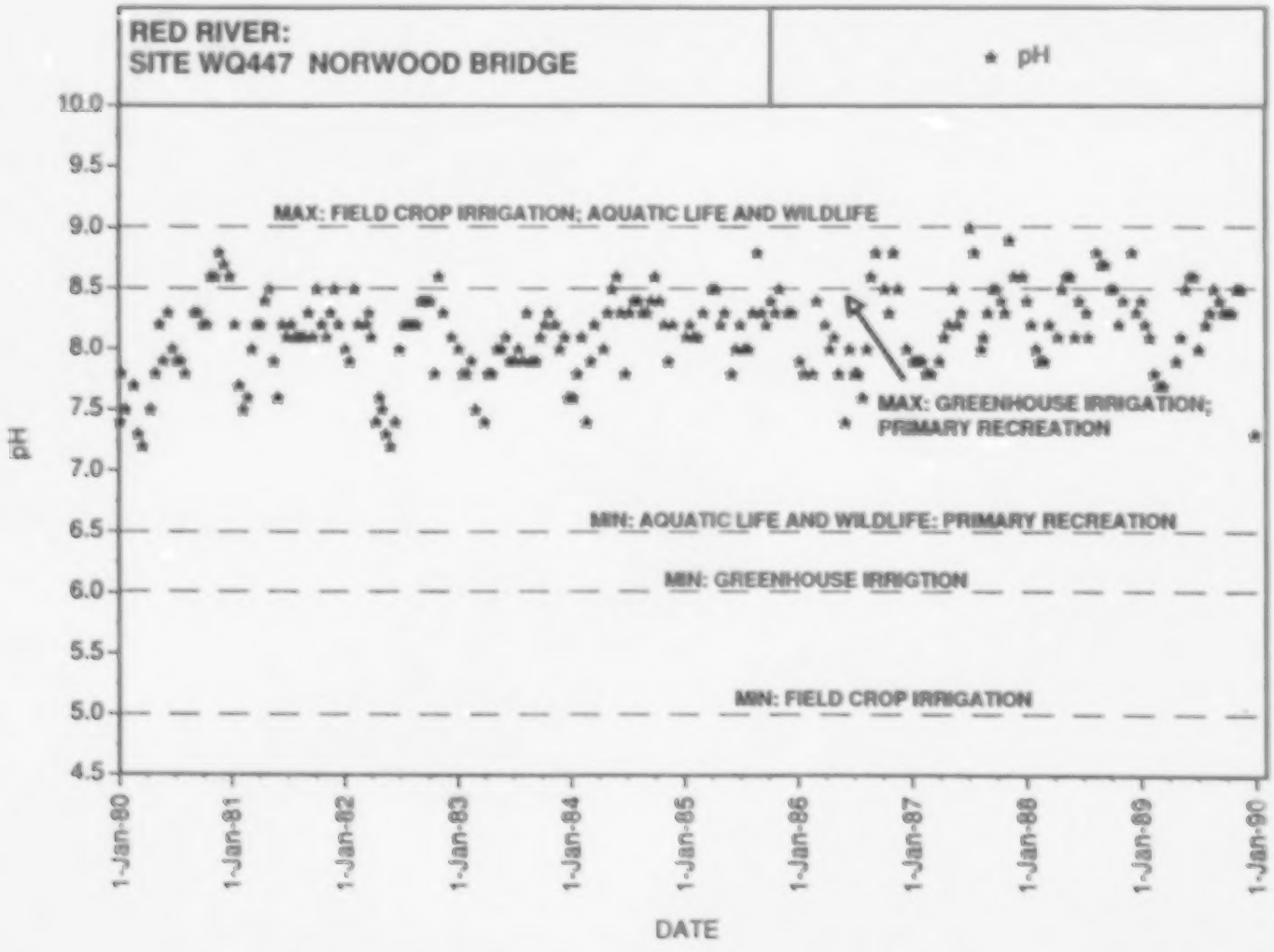


TABLE A68: Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ447 at Norwood Bridge on the Red River.

SITE: WQ447 RED RIVER AT THE NORWOOD BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.1	7.2	9.0	0.35	234	25	10.7%	
1980	8.0	7.2	8.8	0.46	24	5	20.8%	
1981	8.1	7.5	8.5	0.27	25	0	0.0%	
1982	8.0	7.2	8.6	0.40	25	1	4.0%	
1983	7.9	7.4	8.3	0.22	25	0	0.0%	
1984	8.2	7.4	8.6	0.31	23	2	8.7%	
1985	8.2	7.8	8.8	0.21	23	1	4.3%	
1986	8.1	7.4	8.8	0.38	21	3	14.3%	
1987	8.3	7.8	9.0	0.35	23	5	21.7%	
1988	8.4	7.9	8.8	0.27	23	6	26.1%	
1989	8.2	7.3	8.6	0.34	22	2	9.1%	
JAN (80-89)	7.9	7.4	8.4	0.27	21	0	0.0%	
FEB (80-89)	7.9	7.4	8.5	0.27	18	0	0.0%	
MARCH (80-89)	7.9	7.2	8.4	0.36	19	0	0.0%	
APRIL (80-89)	8.0	7.4	8.5	0.32	20	0	0.0%	
MAY (80-89)	8.2	7.3	8.6	0.38	19	3	15.8%	
JUNE (80-89)	8.0	7.2	8.6	0.38	21	2	9.5%	
JULY (80-89)	8.1	7.6	9.0	0.32	22	2	9.1%	
AUG (80-89)	8.3	7.8	8.8	0.30	20	4	20.0%	
SEPT (80-89)	8.4	7.9	8.8	0.20	20	2	10.0%	
OCT (80-89)	8.3	7.8	8.6	0.17	22	2	9.1%	
NOV (80-89)	8.4	7.9	8.9	0.28	18	6	33.3%	
DEC (80-89)	8.2	7.3	8.8	0.42	14	4	28.6%	

TABLE A69: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ447 at the Norwood Bridge on the Red River.

SITE: WQ447 RED RIVER AT THE NORWOOD BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.1	7.2	9.0	0.35	234	25	10.7%	
1980	8.0	7.2	8.8	0.46	24	5	20.8%	
1981	8.1	7.5	8.5	0.27	25	0	0.0%	
1982	8.0	7.2	8.6	0.40	25	1	4.0%	
1983	7.9	7.4	8.3	0.22	25	0	0.0%	
1984	8.2	7.4	8.6	0.31	23	2	8.7%	
1985	8.2	7.8	8.8	0.21	23	1	4.3%	
1986	8.1	7.4	8.8	0.38	21	3	14.3%	
1987	8.3	7.8	9.0	0.35	23	5	21.7%	
1988	8.4	7.9	8.8	0.27	23	6	26.1%	
1989	8.2	7.3	8.6	0.34	22	2	9.1%	
JAN (80-89)	7.9	7.4	8.4	0.27	21	0	0.0%	
FEB (80-89)	7.9	7.4	8.5	0.27	18	0	0.0%	
MARCH (80-89)	7.9	7.2	8.4	0.36	19	0	0.0%	
APRIL (80-89)	8.0	7.4	8.5	0.32	20	0	0.0%	
MAY (80-89)	8.2	7.3	8.6	0.38	19	3	15.8%	
JUNE (80-89)	8.0	7.2	8.6	0.38	21	2	9.5%	
JULY (80-89)	8.1	7.6	9.0	0.32	22	2	9.1%	
AUG (80-89)	8.3	7.8	8.8	0.30	20	4	20.0%	
SEPT (80-89)	8.4	7.9	8.8	0.20	20	2	10.0%	
OCT (80-89)	8.3	7.8	8.6	0.17	22	2	9.1%	
NOV (80-89)	8.4	7.9	8.9	0.28	18	6	33.3%	
DEC (80-89)	8.2	7.3	8.8	0.42	14	4	28.6%	

FIGURE A114: pH of the Red River, at site WQ448 at the Redwood Bridge.

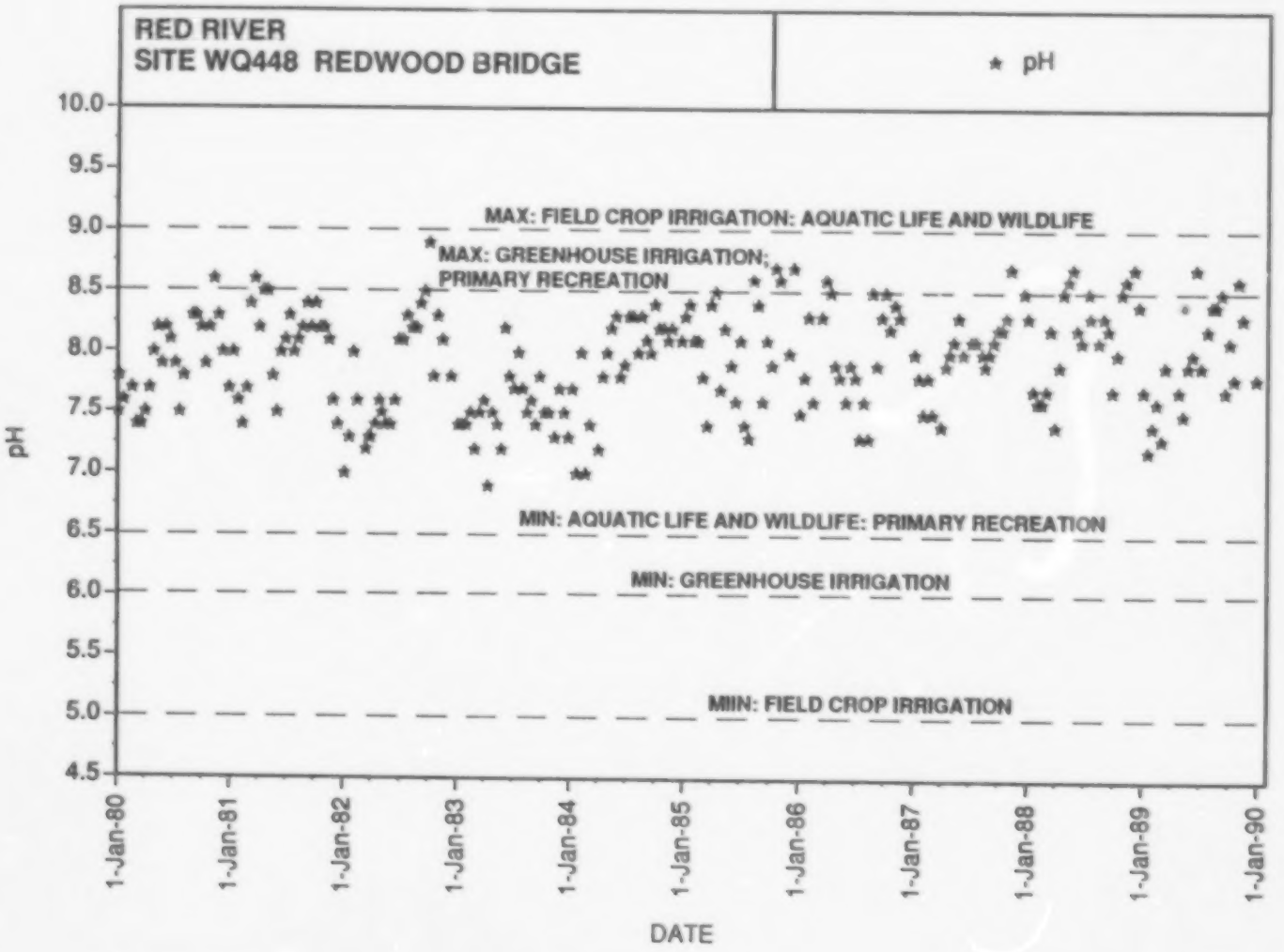


TABLE A70: Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ448 at the Redwood Bridge on the Red River.

SITE: WQ448 RED RIVER AT THE REDWOOD BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	7.9	6.9	8.9	0.41	239	15	6.3%	
1980	7.9	7.4	8.6	0.33	25	1	4.0%	
1981	8.1	7.4	8.6	0.35	25	1	4.0%	
1982	7.8	7.0	8.9	0.48	25	1	4.0%	
1983	7.5	6.9	8.2	0.26	26	0	0.0%	
1984	7.9	7.0	8.4	0.41	24	0	0.0%	
1985	8.1	7.3	8.7	0.42	24	4	16.7%	
1986	8.0	7.3	8.6	0.41	22	1	4.5%	
1987	8.0	7.4	8.7	0.31	22	1	4.5%	
1988	8.2	7.4	8.7	0.38	24	4	16.7%	
1989	7.9	7.2	8.7	0.42	22	2	9.1%	
JAN (80-89)	7.7	7.0	8.4	0.40	21	0	0.0%	
FEB (80-89)	7.7	7.0	8.3	0.30	19	0	0.0%	
MARCH (80-89)	7.6	7.2	8.6	0.42	21	1	4.8%	
APRIL (80-89)	7.9	6.9	8.6	0.47	22	1	4.5%	
MAY (80-89)	8.0	7.2	8.7	0.43	19	2	10.5%	
JUNE (80-89)	7.9	7.4	8.7	0.30	21	1	4.8%	
JULY (80-89)	8.0	7.3	8.5	0.35	22	0	0.0%	
AUG (80-89)	8.1	7.3	8.6	0.35	20	1	5.0%	
SEPT (80-89)	8.1	7.4	8.5	0.30	21	0	0.0%	
OCT (80-89)	8.2	7.5	8.9	0.35	22	2	9.1%	
NOV (80-89)	8.3	7.3	8.7	0.35	17	5	29.4%	
DEC (80-89)	8.0	7.3	8.7	0.47	14	2	14.3%	

TABLE A71: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ448 at Redwood Bridge on the Red River.

SITE: WQ448 RED RIVER AT THE REDWOOD BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	7.9	6.9	8.9	0.41	239	15	6.3%	
1980	7.9	7.4	8.6	0.33	25	1	4.0%	
1981	8.1	7.4	8.6	0.35	25	1	4.0%	
1982	7.8	7.0	8.9	0.48	25	1	4.0%	
1983	7.5	6.9	8.2	0.26	26	0	0.0%	
1984	7.9	7.0	8.4	0.41	24	0	0.0%	
1985	8.1	7.3	8.7	0.42	24	4	16.7%	
1986	8.0	7.3	8.6	0.41	22	1	4.5%	
1987	8.0	7.4	8.7	0.31	22	1	4.5%	
1988	8.2	7.4	8.7	0.38	24	4	16.7%	
1989	7.9	7.2	8.7	0.42	22	2	9.1%	
JAN (80-89)	7.7	7.0	8.4	0.40	21	0	0.0%	
FEB (80-89)	7.7	7.0	8.3	0.30	19	0	0.0%	
MARCH (80-89)	7.6	7.2	8.6	0.42	21	1	4.8%	
APRIL (80-89)	7.9	6.9	8.6	0.47	22	1	4.5%	
MAY (80-89)	8.0	7.2	8.7	0.43	19	2	10.5%	
JUNE (80-89)	7.9	7.4	8.7	0.30	21	1	4.8%	
JULY (80-89)	8.0	7.3	8.5	0.35	22	0	0.0%	
AUG (80-89)	8.1	7.3	8.6	0.35	20	1	5.0%	
SEPT (80-89)	8.1	7.4	8.5	0.30	21	0	0.0%	
OCT (80-89)	8.2	7.5	8.9	0.35	22	2	9.1%	
NOV (80-89)	8.3	7.3	8.7	0.35	17	5	29.4%	
DEC (80-89)	8.0	7.3	8.7	0.47	14	2	14.3%	

FIGURE A115: pH of the Red River, at site WQ449 at the north perimeter.

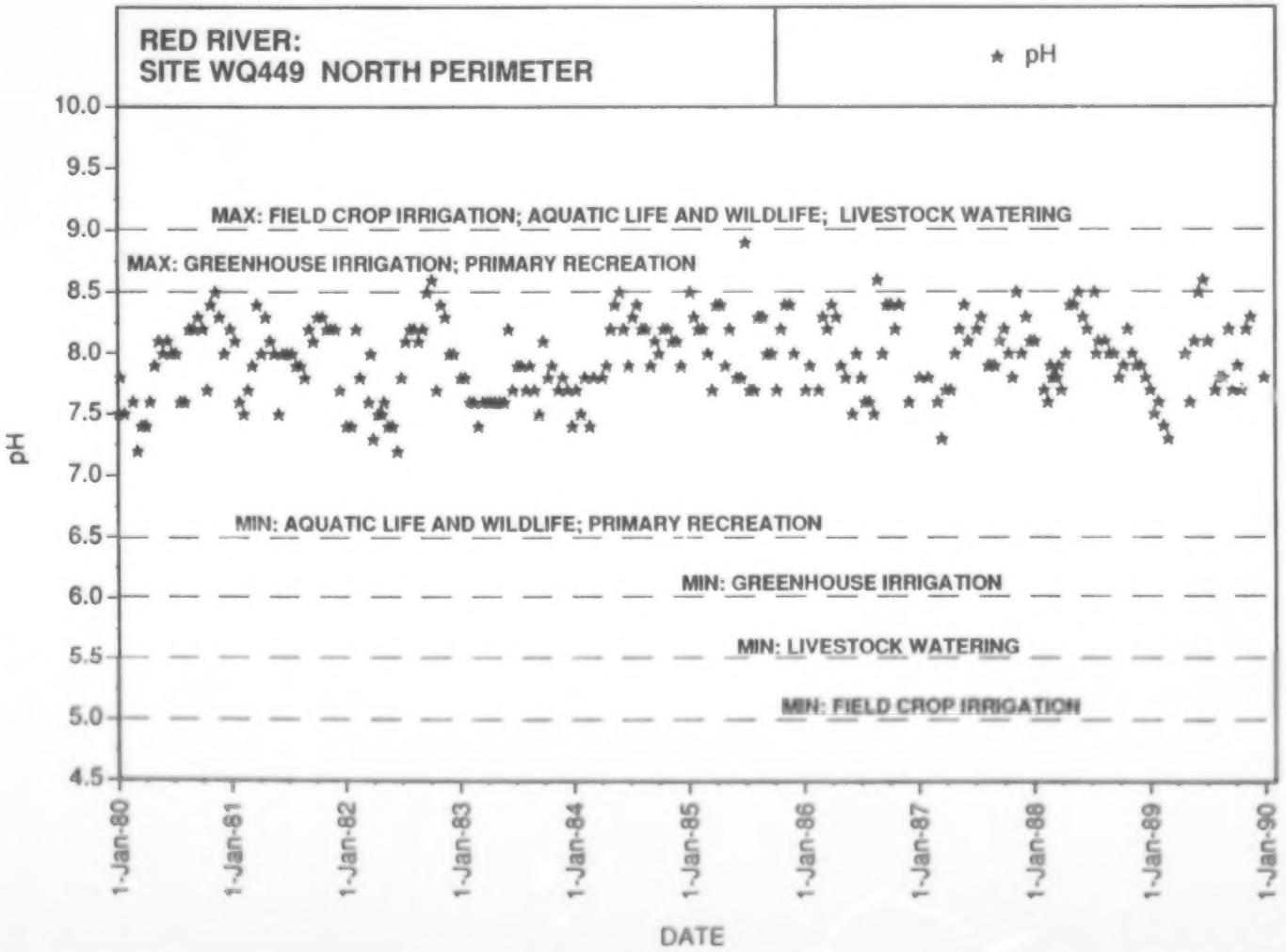


TABLE A72: Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	7.9	7.2	8.9	0.32	245	4	1.6%	
1980	7.9	7.2	8.5	0.35	26	0	0.0%	
1981	8.0	7.5	8.4	0.25	25	0	0.0%	
1982	7.9	7.2	8.6	0.41	26	1	3.8%	
1983	7.7	7.4	8.2	0.19	23	0	0.0%	
1984	8.0	7.4	8.5	0.28	24	0	0.0%	
1985	8.1	7.7	8.9	0.31	24	1	4.2%	
1986	8.0	7.5	8.6	0.35	22	1	4.5%	
1987	8.0	7.3	8.5	0.28	23	0	0.0%	
1988	8.0	7.6	8.5	0.24	28	0	0.0%	
1989	7.9	7.3	8.6	0.35	21	1	4.8%	
JAN (80-89)	7.8	7.4	8.5	0.30	20	0	0.0%	
FEB (80-89)	7.7	7.4	8.2	0.26	17	0	0.0%	
MARCH (80-89)	7.7	7.2	8.4	0.32	24	0	0.0%	
APRIL (80-89)	7.9	7.4	8.4	0.33	22	0	0.0%	
MAY (80-89)	8.0	7.4	8.5	0.35	19	0	0.0%	
JUNE (80-89)	7.9	7.2	8.6	0.35	21	1	4.8%	
JULY (80-89)	8.0	7.6	8.9	0.32	23	1	4.3%	
AUG (80-89)	8.0	7.5	8.6	0.27	21	1	4.8%	
SEPT (80-89)	8.1	7.5	8.5	0.23	21	0	0.0%	
OCT (80-89)	8.1	7.7	8.6	0.27	22	1	4.5%	
NOV (80-89)	8.2	7.7	8.5	0.23	20	0	0.0%	
DEC (80-89)	7.9	7.4	8.3	0.25	15	0	0.0%	

TABLE A73: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ449 at the north perimeter on the Red River.

SITE: WQ449 RED RIVER AT THE NORTH PERIMETER
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	7.9	7.2	8.9	0.32	245	4	1.6%	
1980	7.9	7.2	8.5	0.35	26	0	0.0%	
1981	8.0	7.5	8.4	0.25	25	0	0.0%	
1982	7.9	7.2	8.6	0.41	26	1	3.8%	
1983	7.7	7.4	8.2	0.19	26	0	0.0%	
1984	8.0	7.4	8.5	0.28	24	0	0.0%	
1985	8.1	7.7	8.9	0.31	24	1	4.2%	
1986	8.0	7.5	8.6	0.35	22	1	4.5%	
1987	8.0	7.3	8.5	0.28	23	0	0.0%	
1988	8.0	7.6	8.5	0.24	28	0	0.0%	
1989	7.9	7.3	8.6	0.35	21	1	4.8%	
JAN (80-89)	7.8	7.4	8.5	0.30	20	0	0.0%	
FEB (80-89)	7.7	7.4	8.2	0.26	17	0	0.0%	
MARCH (80-89)	7.7	7.2	8.4	0.32	24	0	0.0%	
APRIL (80-89)	7.9	7.4	8.4	0.33	22	0	0.0%	
MAY (80-89)	8.0	7.4	8.5	0.35	19	0	0.0%	
JUNE (80-89)	7.9	7.2	8.6	0.35	21	1	4.8%	
JULY (80-89)	8.0	7.6	8.9	0.32	23	1	4.3%	
AUG (80-89)	8.0	7.5	8.6	0.27	21	1	4.8%	
SEPT (80-89)	8.1	7.5	8.5	0.23	21	0	0.0%	
OCT (80-89)	8.1	7.7	8.6	0.27	22	1	4.5%	
NOV (80-89)	8.2	7.7	8.5	0.23	20	0	0.0%	
DEC (80-89)	7.9	7.4	8.3	0.25	15	0	0.0%	

FIGURE A116: pH of the Red River, at site WQ450 at Lockport.

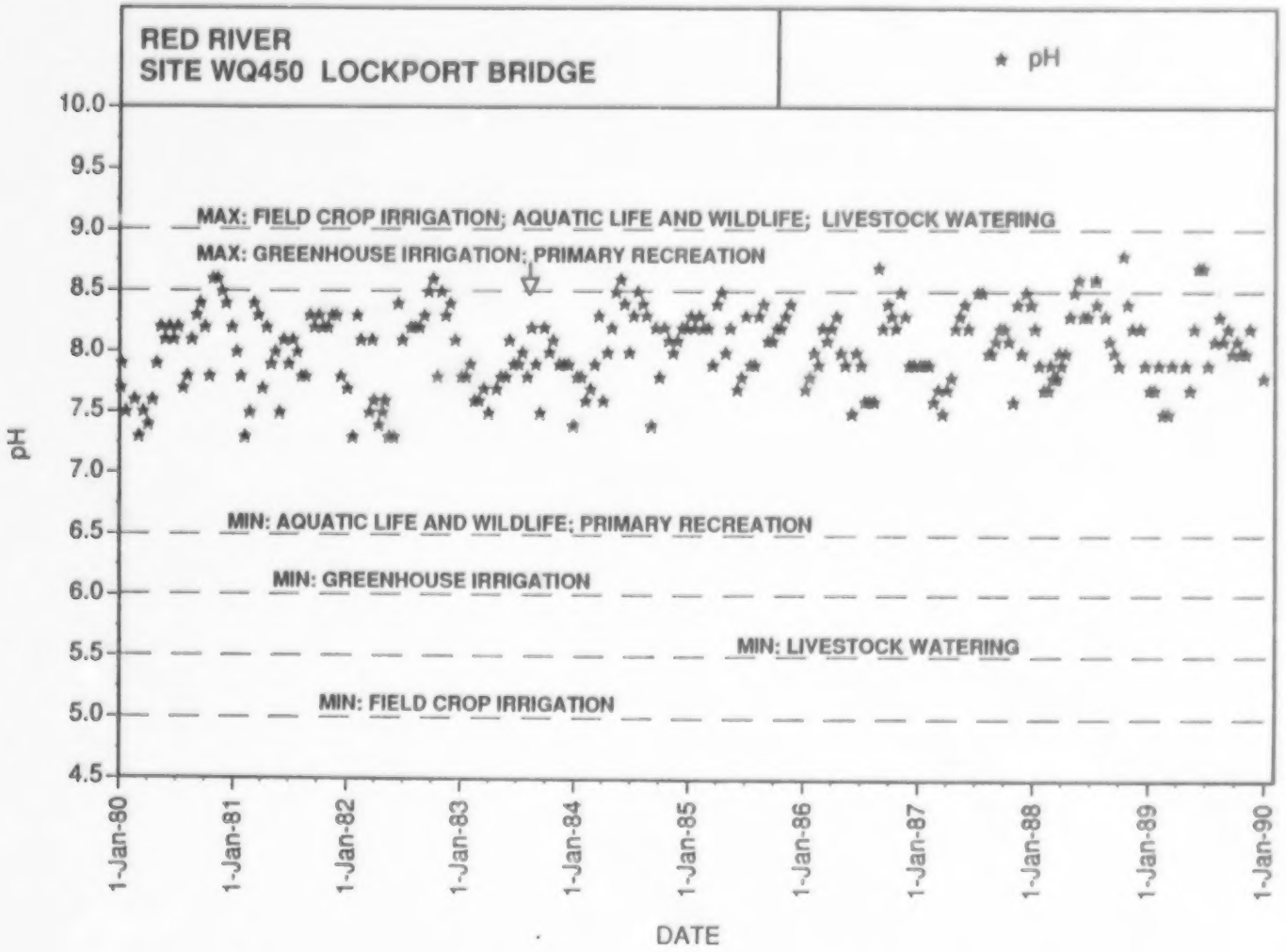


TABLE A74: **Summary statistics and exceedence of the pH objective for the protection of primary recreation use, at site WQ450 at Lockport on the Red River.**

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: PRIMARY RECREATION
OBJECTIVE: MIN=6.5, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.0	7.3	8.8	0.32	249	10	4.0%	
1980	8.0	7.3	8.6	0.38	26	2	7.7%	
1981	8.0	7.3	8.4	0.29	25	0	0.0%	
1982	8.0	7.3	8.6	0.43	25	1	4.0%	
1983	7.8	7.4	8.2	0.21	25	0	0.0%	
1984	8.1	7.4	8.6	0.31	26	1	3.8%	
1985	8.1	7.7	8.5	0.23	25	0	0.0%	
1986	8.1	7.5	8.7	0.31	23	1	4.3%	
1987	8.1	7.5	8.5	0.30	25	0	0.0%	
1988	8.1	7.7	8.8	0.30	27	3	11.1%	
1989	8.0	7.5	8.7	0.31	22	2	9.1%	
JAN (80-89)	7.8	7.3	8.3	0.24	19	0	0.0%	
FEB (80-89)	7.8	7.3	8.3	0.28	20	0	0.0%	
MARCH (80-89)	7.8	7.3	8.4	0.30	26	0	0.0%	
APRIL (80-89)	7.9	7.4	8.5	0.33	21	0	0.0%	
MAY (80-89)	8.1	7.3	8.6	0.36	19	2	10.5%	
JUNE (80-89)	8.1	7.3	8.7	0.37	21	2	9.5%	
JULY (80-89)	8.1	7.6	8.6	0.30	21	1	4.8%	
AUG (80-89)	8.1	7.6	8.7	0.26	21	1	4.8%	
SEPT (80-89)	8.1	7.4	8.5	0.27	21	0	0.0%	
OCT (80-89)	8.2	7.6	8.8	0.28	22	3	13.6%	
NOV (80-89)	8.3	7.9	8.6	0.21	20	1	5.0%	
DEC (80-89)	8.0	7.4	8.5	0.29	18	0	0.0%	

TABLE A75: Summary statistics and exceedence of the pH objective for the protection of greenhouse irrigation use, at site WQ450 at Lockport on the Red River.

SITE: WQ450 RED RIVER AT THE LOCKPORT BRIDGE
PARAMETER: pH
MSWQO CLASSIFICATION: GREENHOUSE IRRIGATION
OBJECTIVE: MIN=6.0, MAX=8.5 (pH units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

SAMPLE PERIOD	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
1980-1989	8.0	7.3	8.8	0.32	249	10	4.0%	
1980	8.0	7.3	8.6	0.38	26	2	7.7%	
1981	8.0	7.3	8.4	0.29	25	0	0.0%	
1982	8.0	7.3	8.6	0.43	25	1	4.0%	
1983	7.8	7.4	8.2	0.21	25	0	0.0%	
1984	8.1	7.4	8.6	0.31	26	1	3.8%	
1985	8.1	7.7	8.5	0.23	25	0	0.0%	
1986	8.1	7.5	8.7	0.31	23	1	4.3%	
1987	8.1	7.5	8.5	0.30	25	0	0.0%	
1988	8.1	7.7	8.8	0.30	27	3	11.1%	
1989	8.0	7.5	8.7	0.31	22	2	9.1%	
JAN (80-89)	7.8	7.3	8.3	0.24	19	0	0.0%	
FEB (80-89)	7.8	7.3	8.3	0.28	20	0	0.0%	
MARCH (80-89)	7.8	7.3	8.4	0.30	26	0	0.0%	
APRIL (80-89)	7.9	7.4	8.5	0.33	21	0	0.0%	
MAY (80-89)	8.1	7.3	8.6	0.36	19	2	10.5%	
JUNE (80-89)	8.1	7.3	8.7	0.37	21	2	9.5%	
JULY (80-89)	8.1	7.6	8.6	0.30	21	1	4.8%	
AUG (80-89)	8.1	7.6	8.7	0.26	21	1	4.8%	
SEPT (80-89)	8.1	7.4	8.5	0.27	21	0	0.0%	
OCT (80-89)	8.2	7.6	8.8	0.28	22	3	13.6%	
NOV (80-89)	8.3	7.9	8.6	0.21	20	1	5.0%	
DEC (80-89)	8.0	7.4	8.5	0.29	18	0	0.0%	

FIGURE A117: pH of the Red River, at site WQ142 at Selkirk.

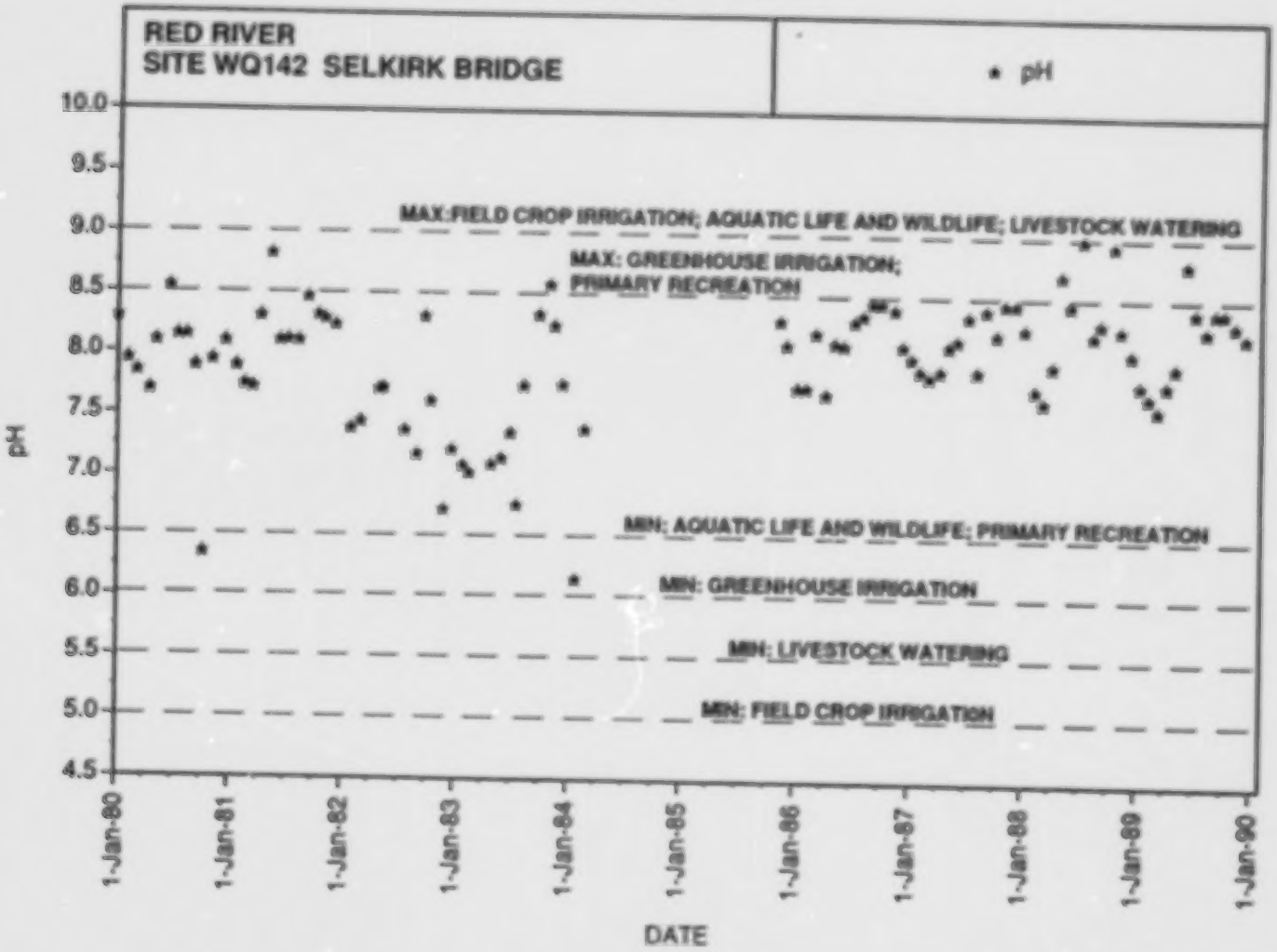


TABLE A76: Trend analysis and paired t-test results on pH data.

TREND ANALYSIS RESULTS: pH. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)					
SAMPLING LOCATION	R2	P VALUE		TREND	N
ASSINIBOINE RIVER SITES:					
WQ018 SOUTH OF HEADINGLEY	0.00	0.849	N/S	INCREASING	201
WQ451 HEADINGLEY	0.04	0.001	**	INCREASING	288
WQ452 WEST PERIMETER	0.01	0.087	N/S	INCREASING	292
WQ453 MAIN STREET BRIDGE	0.04	0.001	**	INCREASING	281
RED RIVER SITES:					
WQ367 SOUTH GATE OF FLOODWAY	0.08	0.001	**	INCREASING	123
WQ445 FLOODWAY CONTROL	0.08	0.000	**	INCREASING	302
WQ576 FORT GARY BRIDGE	0.18	0.000	**	INCREASING	184
WQ447 NORWOOD BRIDGE	0.08	0.000	**	INCREASING	280
WQ448 REDWOOD BRIDGE	0.00	0.378	N/S	INCREASING	286
WQ449 NORTH PERIMETER	0.00	0.796	N/S	INCREASING	291
WQ450 LOCKPORT BRIDGE	0.01	0.504	N/S	INCREASING	298
WQ142 SELKIRK	0.00	0.783	N/S	DECREASING	226

PAIRED T-TEST RESULTS: pH DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)					
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE		MEAN DIFFERENCE (pH Units)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.001	**	0.178	76
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.050	N/S	0.074	90
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.108	N/S	0.081	78

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
- indicates insufficient data to perform analysis

FIGURE A118: Inorganic carbon concentrations in the Assiniboine River, at site WQ018 at Headingley.

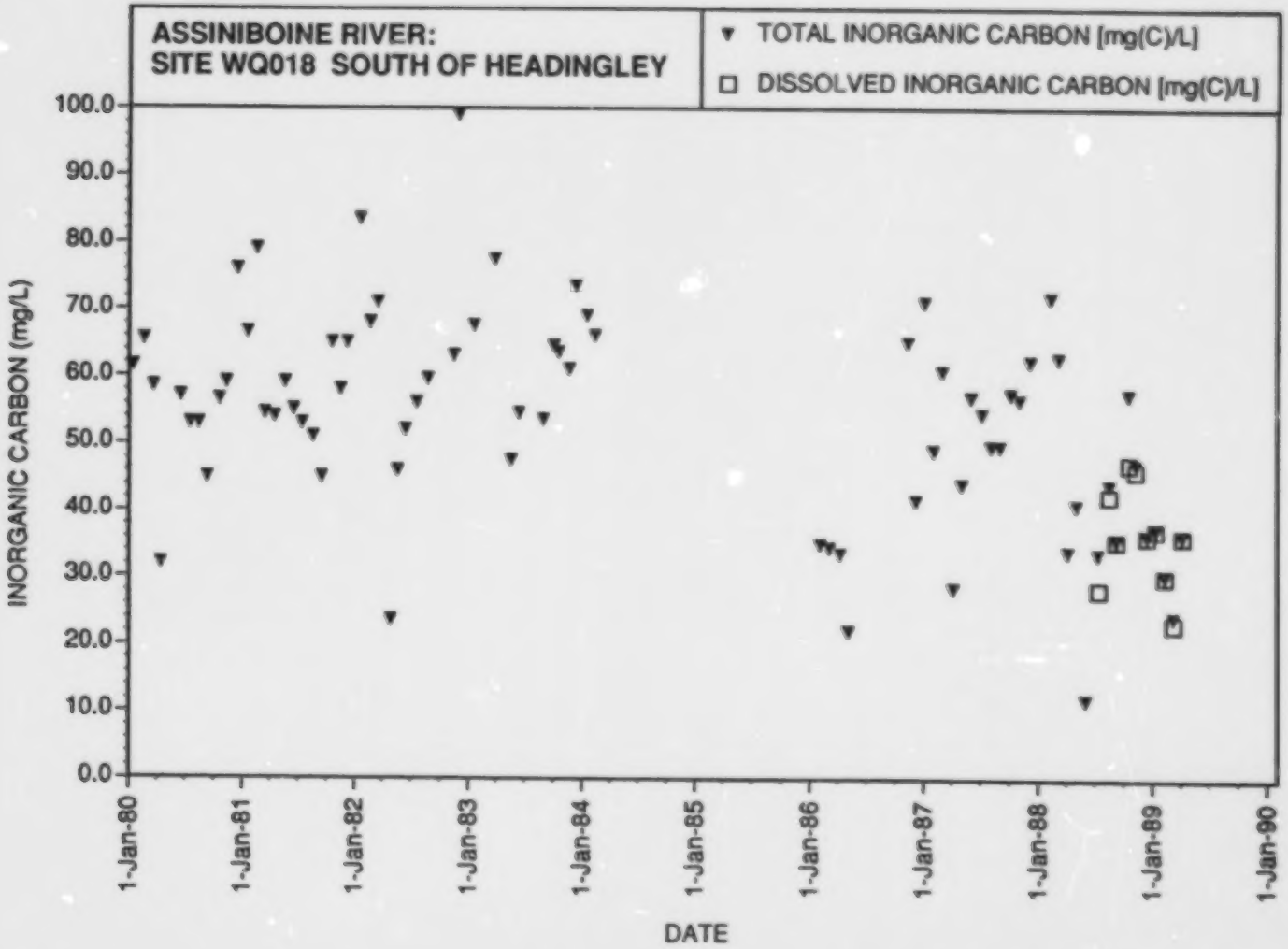


FIGURE A119: Inorganic carbon concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

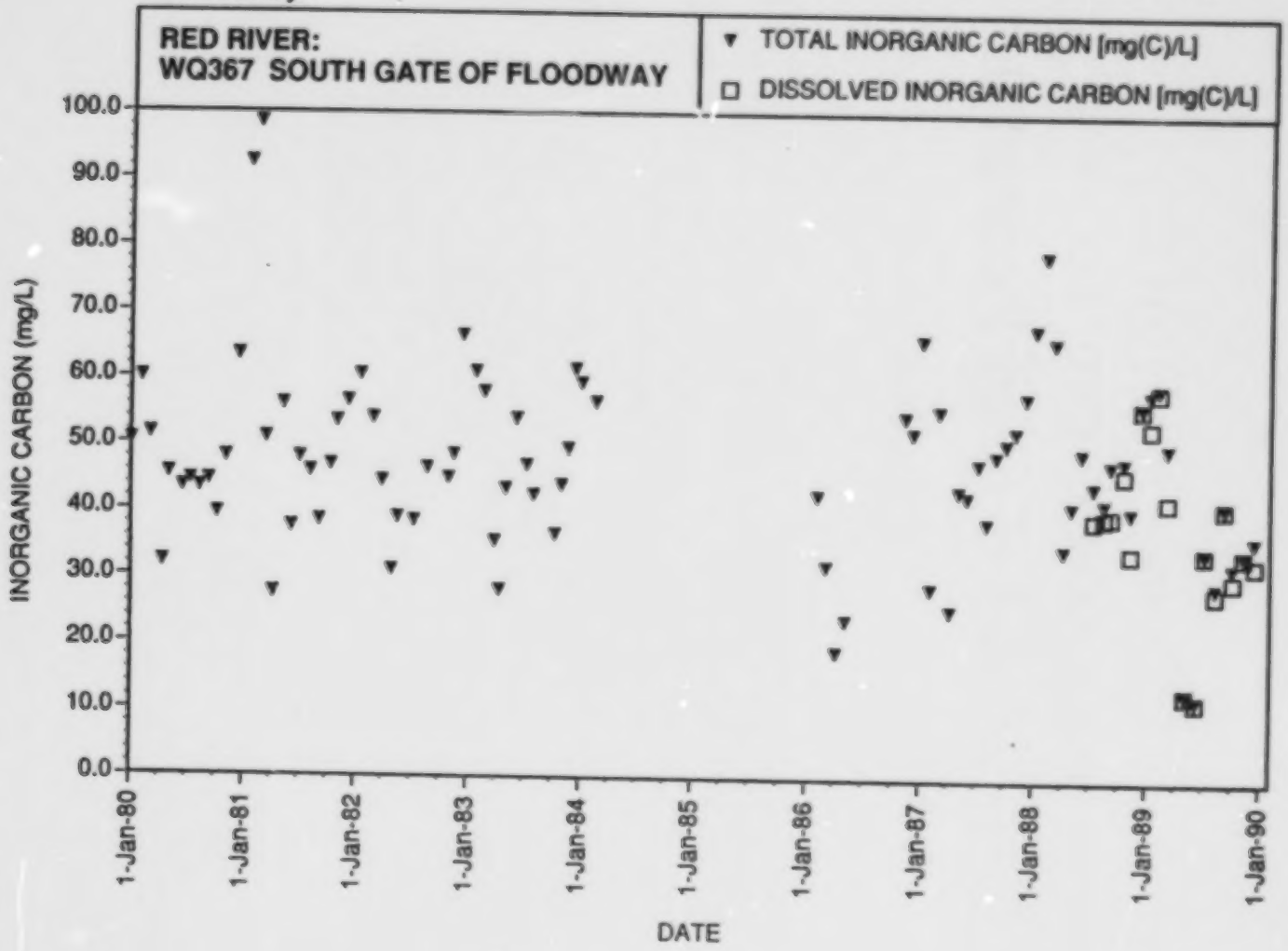


FIGURE A120: Inorganic carbon concentrations in the Red River, at site WQ142 at Selkirk.

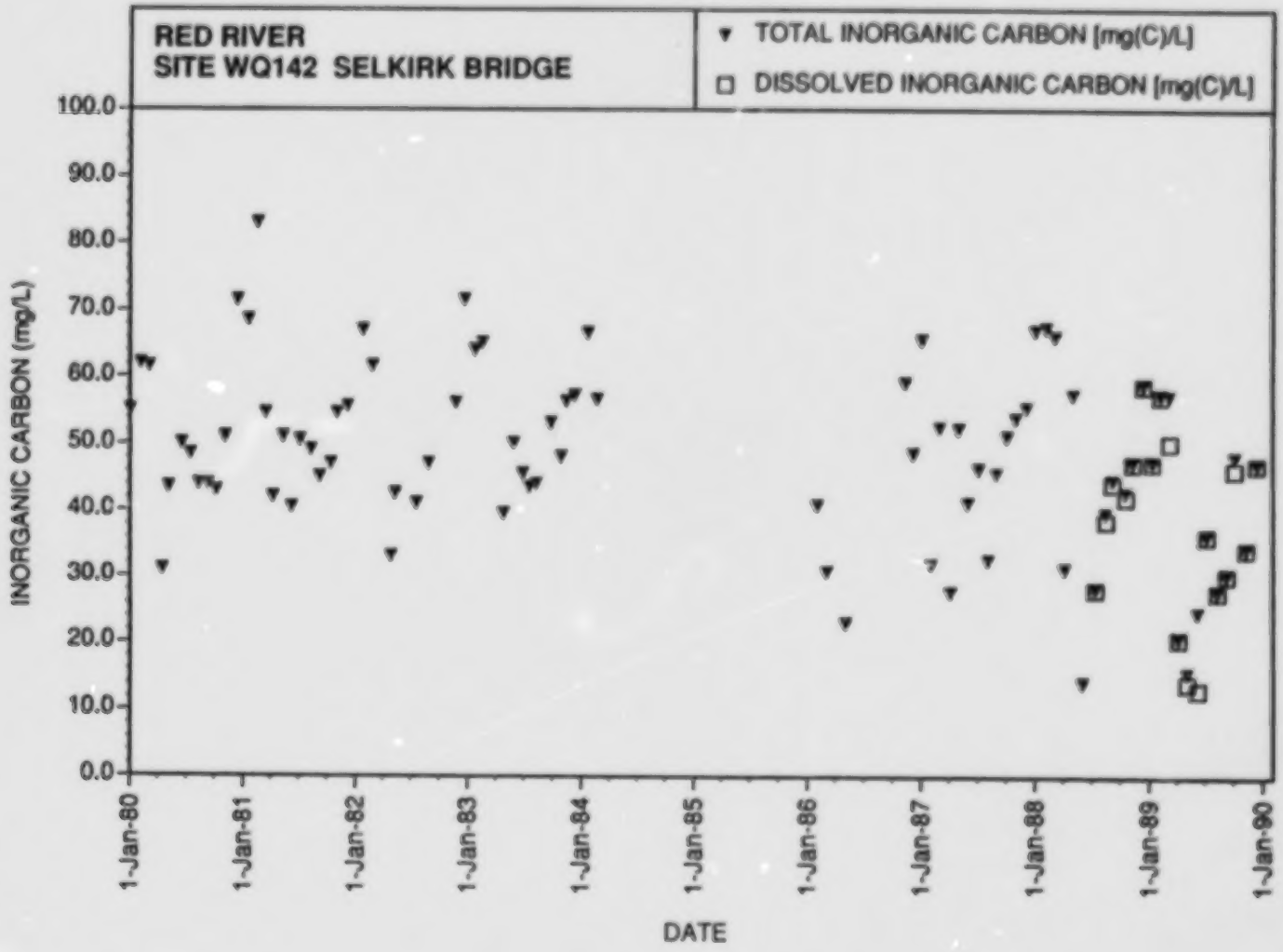


TABLE A77: Trend analysis and paired t-test results on total inorganic carbon data.

TREND ANALYSIS RESULTS: TOTAL INORGANIC CARBON. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.04	0.036 *	DECREASING	120
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.02	0.160 N/S	DECREASING	111
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.03	0.038 *	DECREASING	150

PAIRED T-TEST RESULTS: TOTAL INORGANIC CARBON DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.021 *	3.17	62
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.742 N/S	-0.287	78
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.015 *	4.56	64

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

FIGURE A121: Alkalinity and hardness concentrations in the Assiniboine River, at site WQ018 at Headingley.

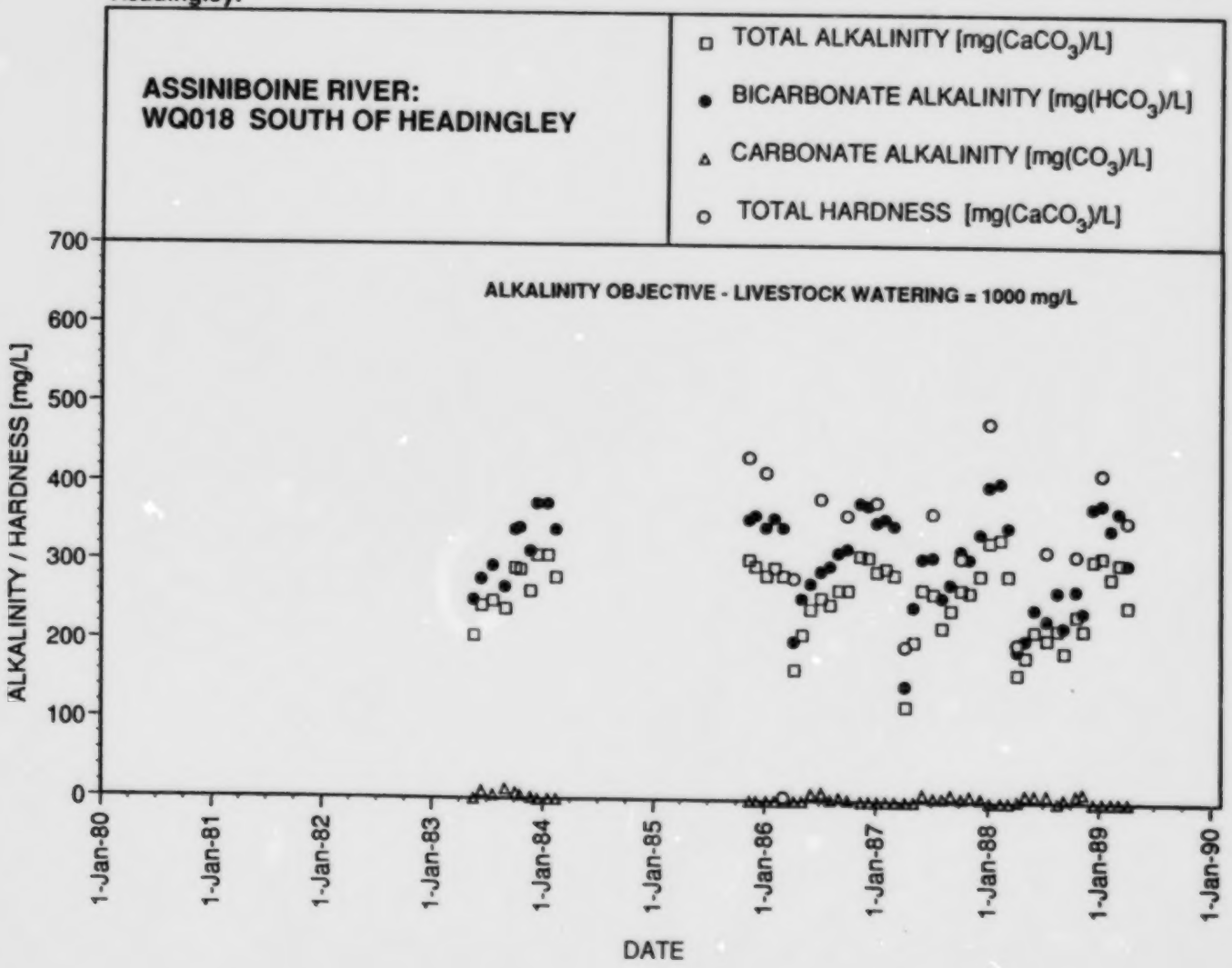


FIGURE A122: Alkalinity and hardness concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

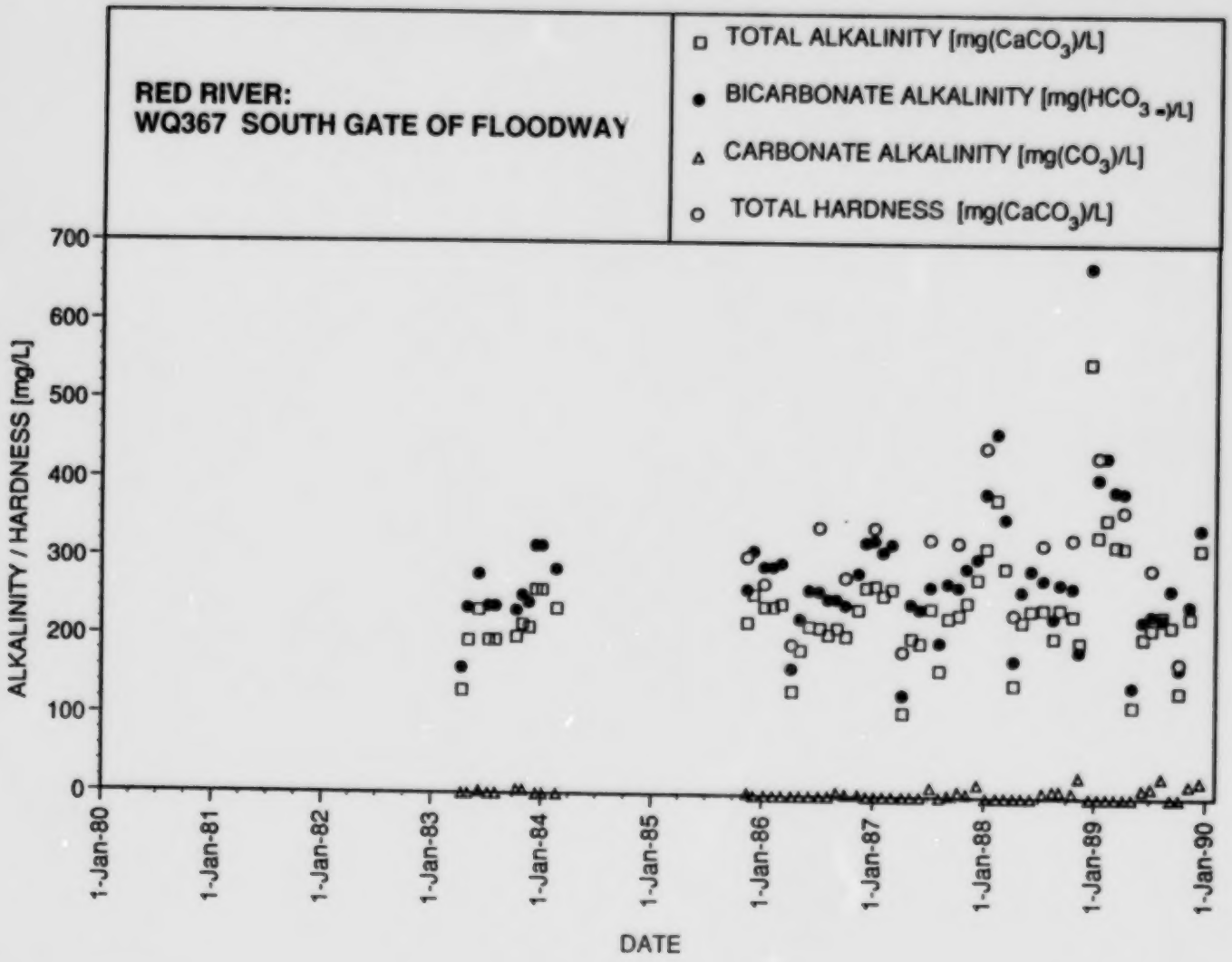


FIGURE A123: Alkalinity and hardness concentrations in the Red River, at site WQ142 at Selkirk.

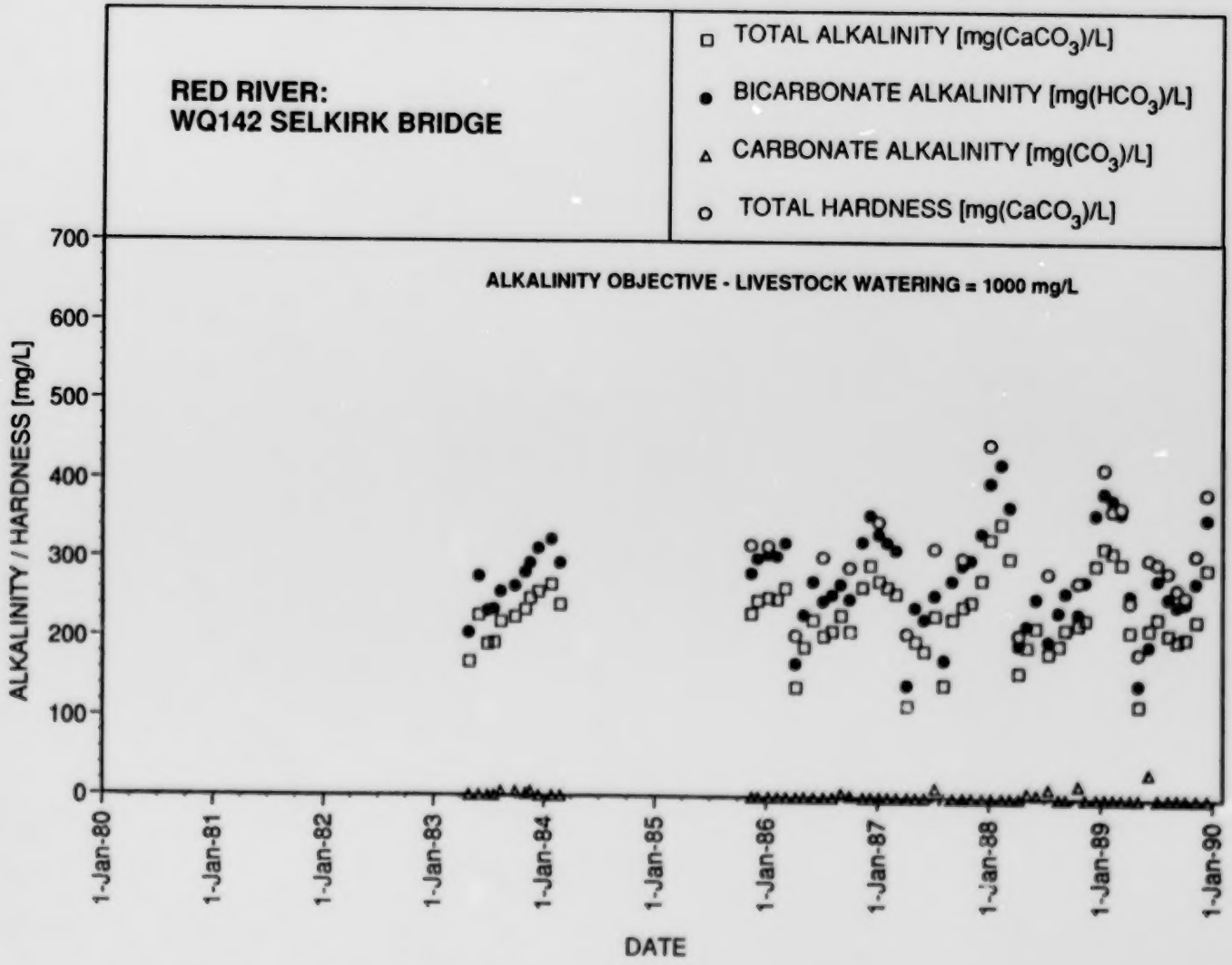


TABLE A78: Trend analysis and paired t-test results on total alkalinity data.

TREND ANALYSIS RESULTS: TOTAL ALKALINITY. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.003	0.566 N/S	DECREASING	112
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.052	0.079 N/S	INCREASING	60
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.018	0.086 N/S	INCREASING	168

PAIRED T-TEST RESULTS: TOTAL ALKALINITY DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.000 **	22.5	48
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.282 N/S	6.14	55
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.065 N/S	14.7	47

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

TABLE A79: Trend analysis and paired t-test results on bicarbonate alkalinity data.

TREND ANALYSIS RESULTS: BICARBONATE ALKALINITY. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.00	0.952 N/S	INCREASING	112
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.03	0.187 N/S	INCREASING	60
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.04	0.008 **	INCREASING	166

PAIRED T-TEST RESULTS: BICARBONATE ALKALINITY DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.000 **	23.9	48
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.585 N/S	4.0	55
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.085 N/S	16.7	47

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

TABLE A80: Trend analysis and paired t-test results on carbonate alkalinity data.

TREND ANALYSIS RESULTS: CARBONATE ALKALINITY. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.05	0.020 *	DECREASING	112
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.13	0.006 **	INCREASING	60
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.06	0.002 **	DECREASING	166

PAIRED T-TEST RESULTS: CARBONATE ALKALINITY DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.007 **	1.59	48
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.110 N/S	1.63	54
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.392 N/S	0.64	46

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

TABLE A81: Trend analysis and paired t-test results on total hardness data.

TREND ANALYSIS RESULTS: TOTAL HARDNESS. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.07	0.011 *	DECREASING	96
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:	~	~	~	~
WQ367 SOUTH GATE OF FLOODWAY	0.02	0.551 N/S	INCREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.00	0.709 N/S	INCREASING	132

PAIRED T-TEST RESULTS: TOTAL HARDNESS DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.001 **	47.3	14
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.536 N/S	6.77	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.036 *	33.5	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A124: Calcium, magnesium and potassium concentrations in the Assiniboine River, at site WQ018 at Headingley.

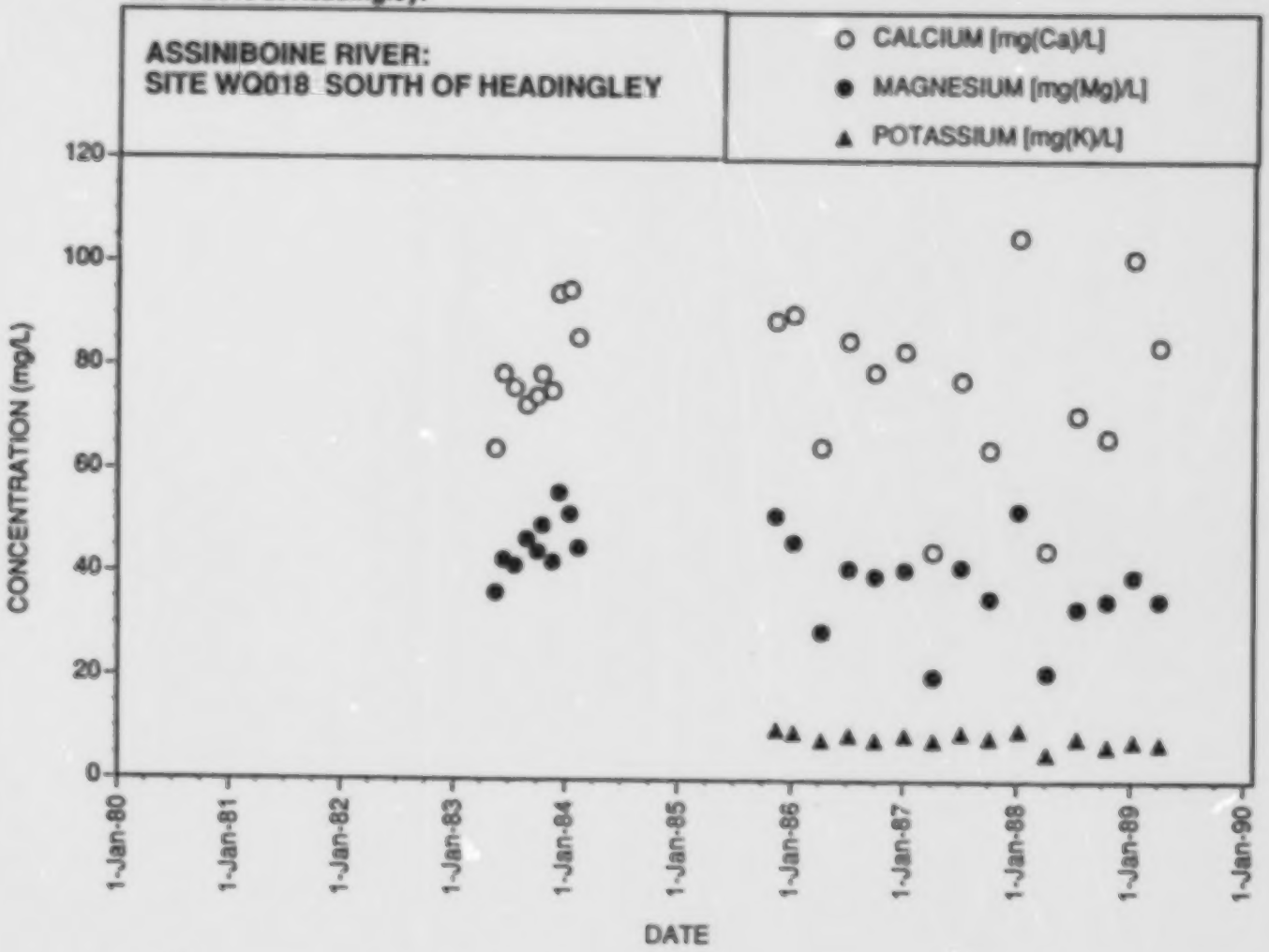


FIGURE A125: Calcium, magnesium and potassium concentrations in the Red River, at site WQ0357 at the south gate of the floodway.

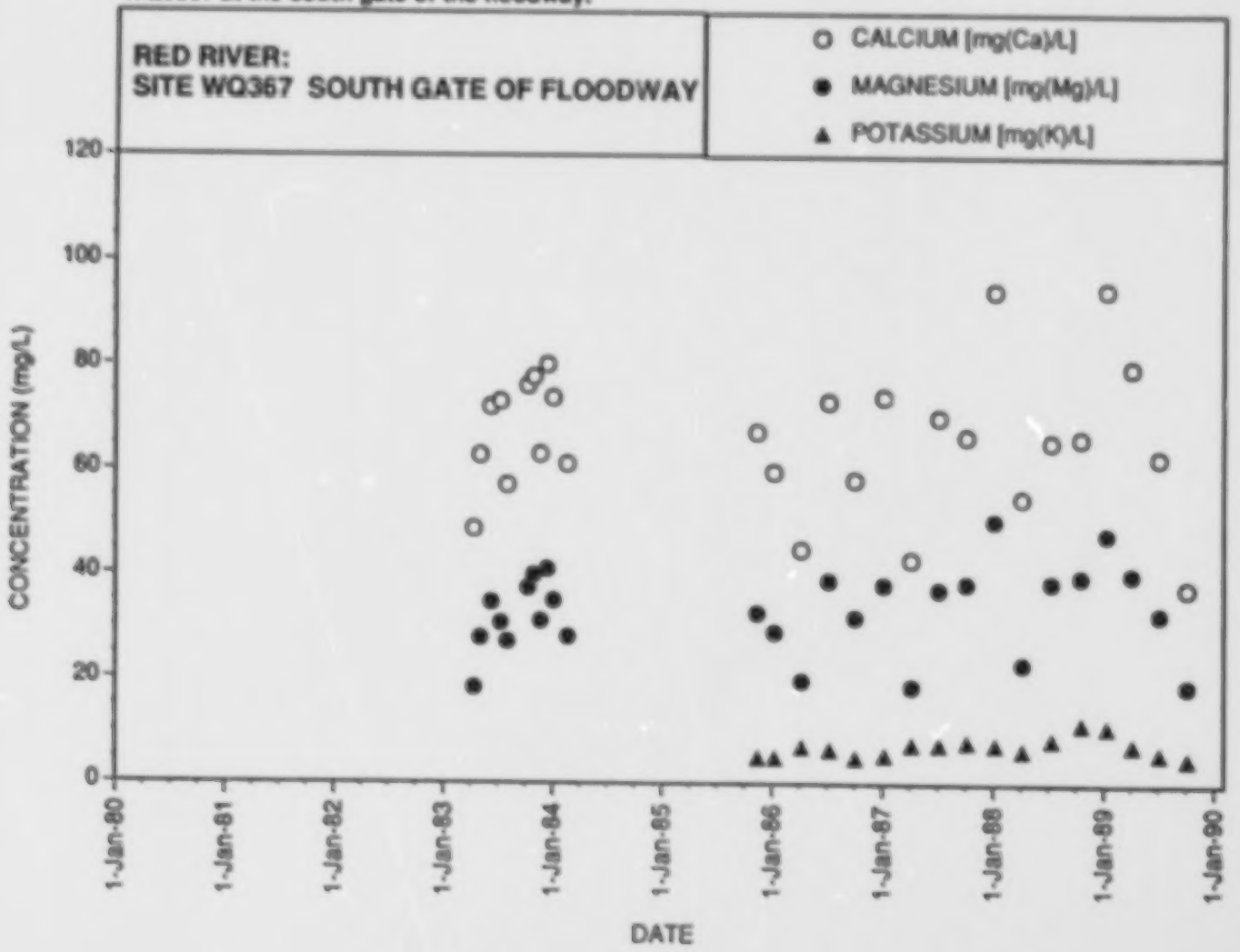


FIGURE A126: Calcium, magnesium and potassium concentrations in the Red River, at site WQ0142 at Selkirk.

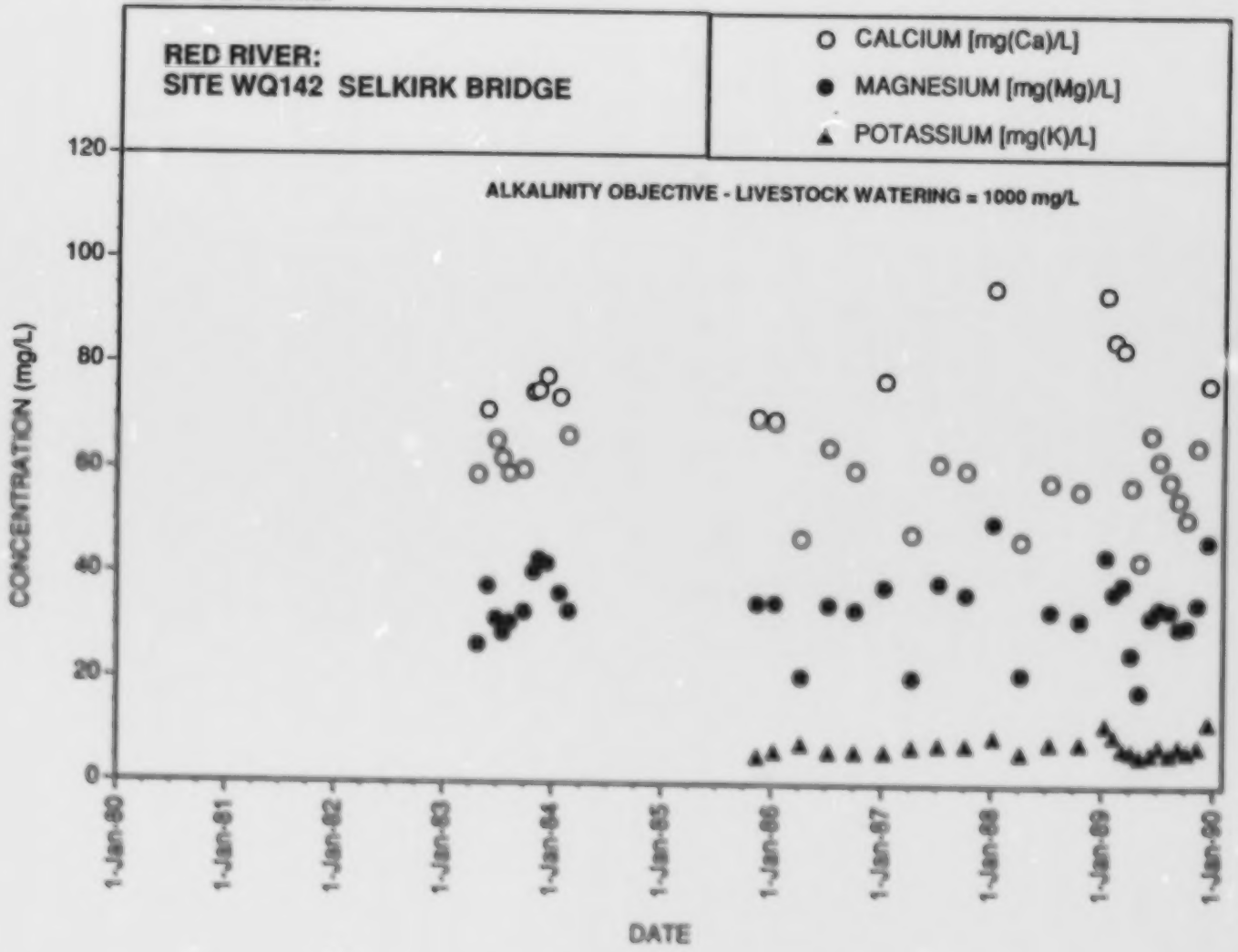


TABLE A82: Trend analysis and paired t-test results on magnesium data.

TREND ANALYSIS RESULTS: MAGNESIUM. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.004	0.691 N/S	INCREASING	41
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:	~	~	~	~
WQ367 SOUTH GATE OF FLOODWAY	0.036	0.331 N/S	INCREASING	28
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.004	0.594 N/S	INCREASING	77

PAIRED T-TEST RESULTS: MAGNESIUM DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.000 **	6.31	21
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.736 N/S	-0.39	23
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.007 **	5.31	20

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

TABLE A83: Trend analysis and paired t-test results on calcium data.

TREND ANALYSIS RESULTS: CALCIUM. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.025	0.333 N/S	INCREASING	39
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:	~	~	~	~
WQ367 SOUTH GATE OF FLOODWAY	0.000	0.925 N/S	DECREASING	28
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.013	0.328 N/S	DECREASING	74

PAIRED T-TEST RESULTS: CALCIUM DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.000 **	11.8	21
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.448 N/S	1.27	23
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.000 ***	9.51	20

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

TABLE A84: Trend analysis and paired t-test results on potassium data.

TREND ANALYSIS RESULTS: POTASSIUM. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.27	0.000 **	DECREASING	55
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.18	0.092 N/S	INCREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.07	0.012 *	DECREASING	93

PAIRED T-TEST RESULTS: POTASSIUM DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1986-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.186 N/S	0.73	14
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.078 N/S	-0.56	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.127 N/S	1.10	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A127: Sulphate concentrations in the Red River, at site WQ018 at Headingley.

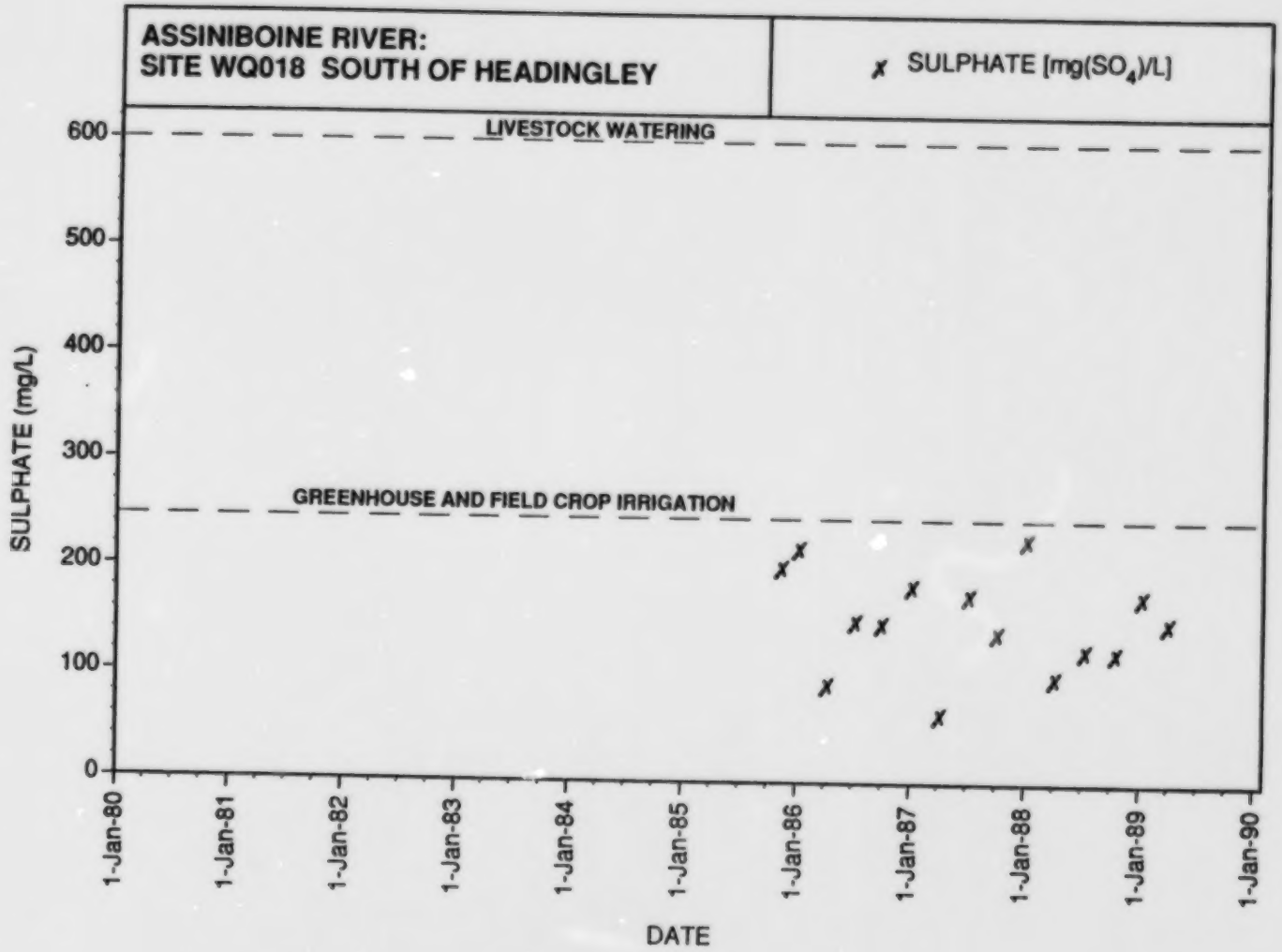


FIGURE A128: Sulphate concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

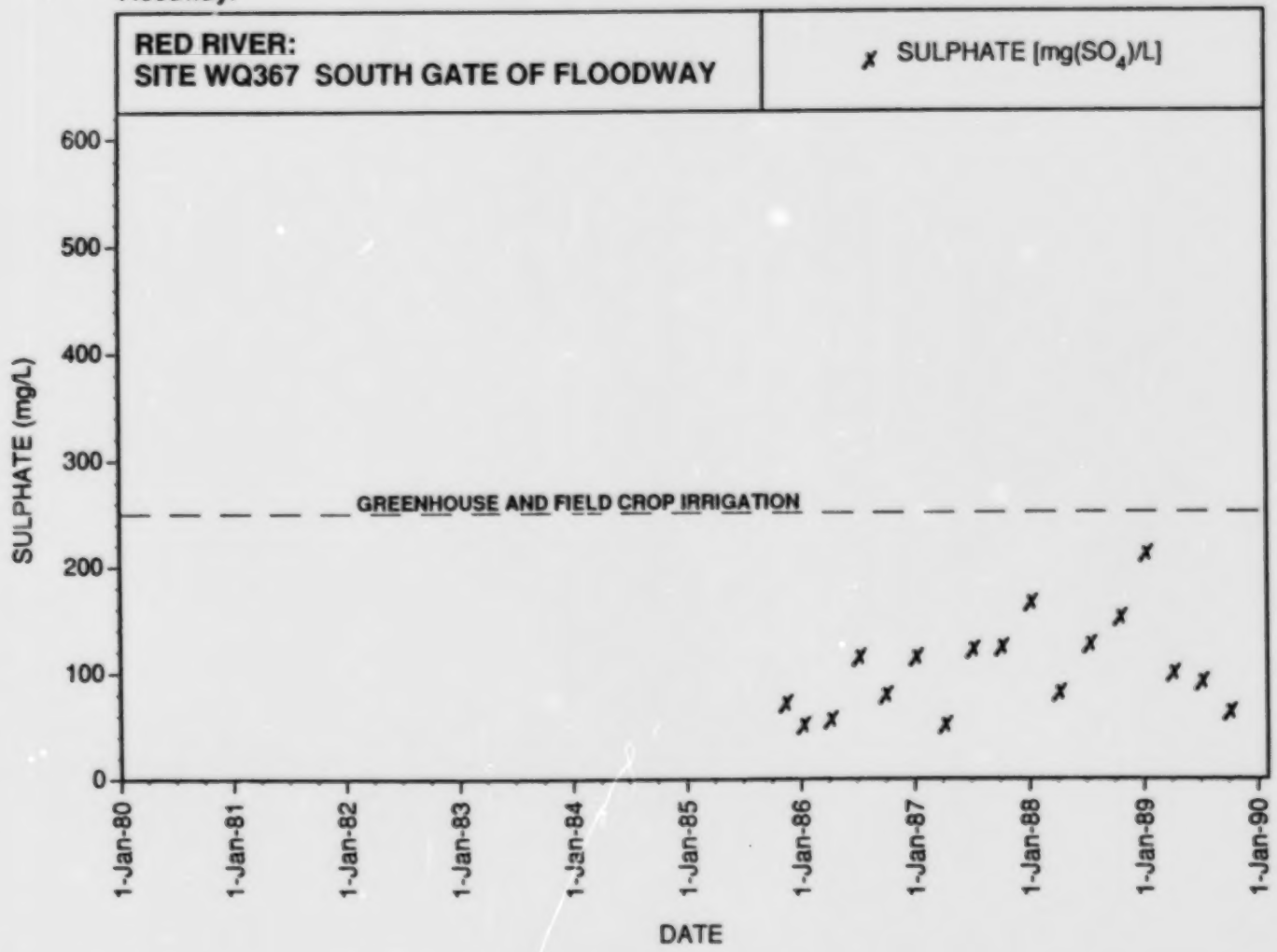


FIGURE A129: Sulphate concentrations in the Red River, at site WQ142 at Selkirk.

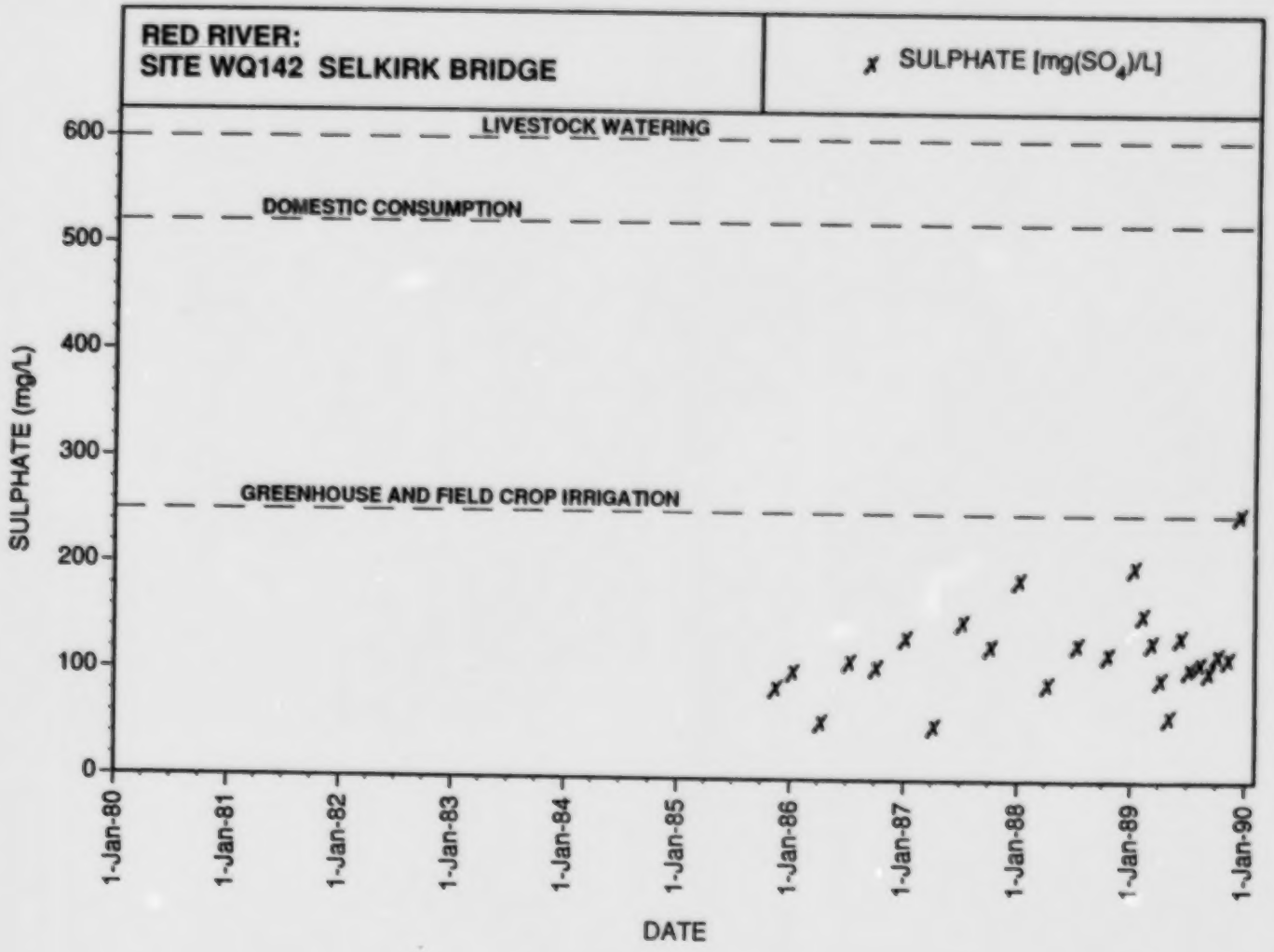


TABLE A85: Trend analysis and paired t-test results on sulphate data.

TREND ANALYSIS RESULTS: SULPHATE. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.11	0.004 **	DECREASING	71
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.16	0.117 N/S	INCREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.01	0.357 N/S	INCREASING	132

PAIRED T-TEST RESULTS: SULPHATE DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.003 **	35.8	14
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.039 *	-11.8	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.007 **	44.4	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A130: Manganese concentrations in the Assiniboine River, at site WQ018 at Headingley.

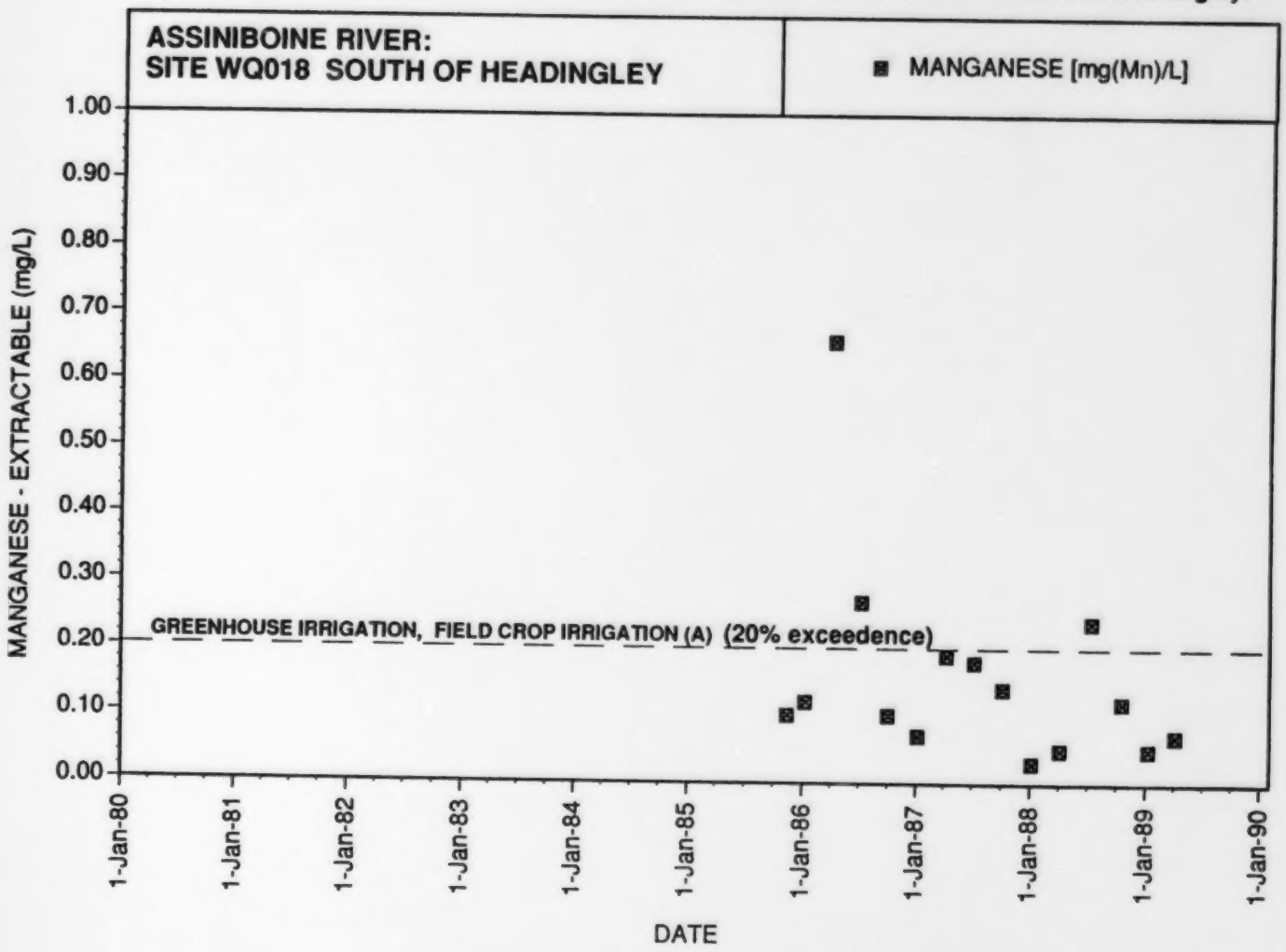


FIGURE A131: Manganese concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

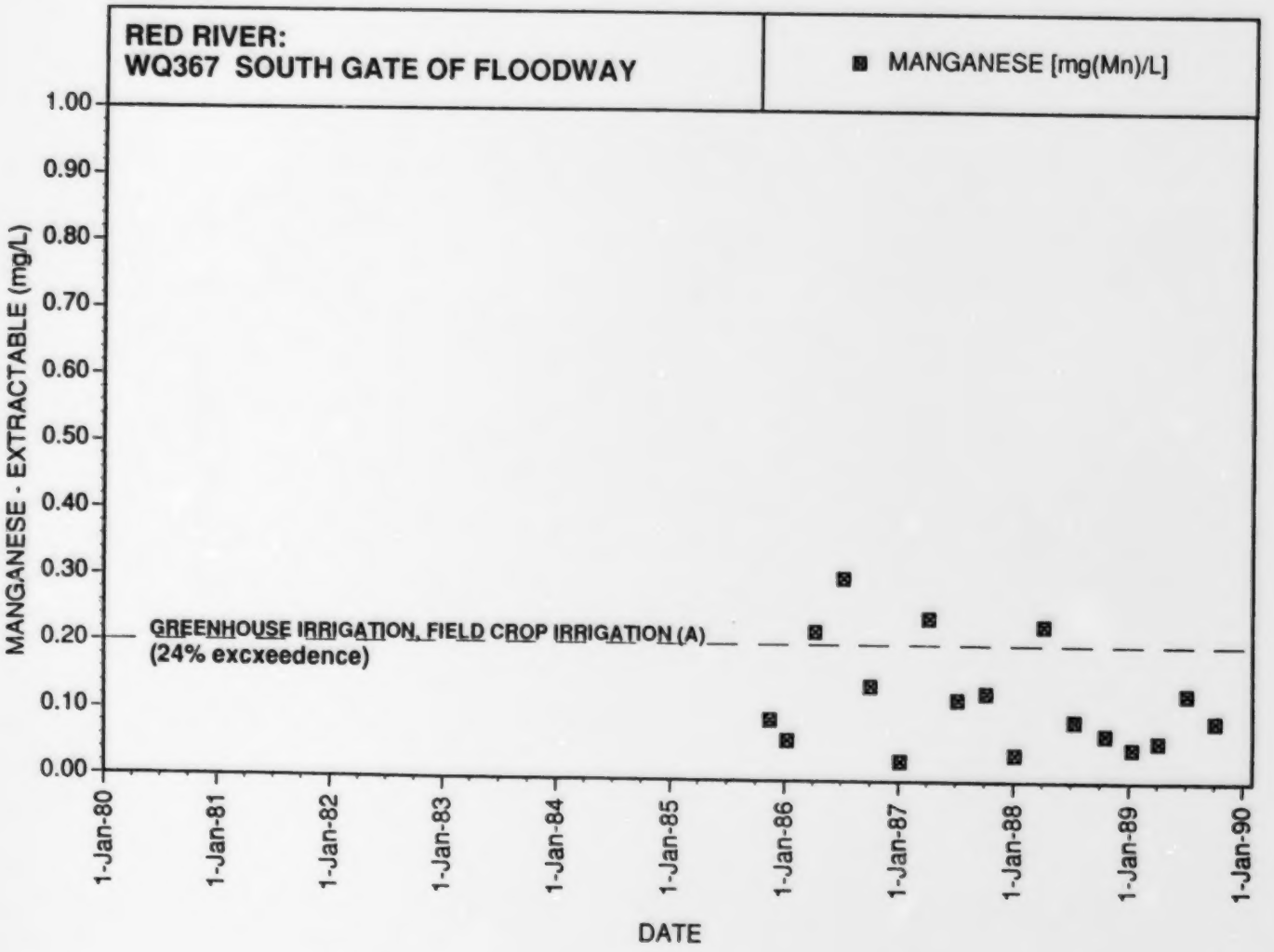


FIGURE A132: Manganese concentrations in the Red River, at site WQ142 at Selkirk.

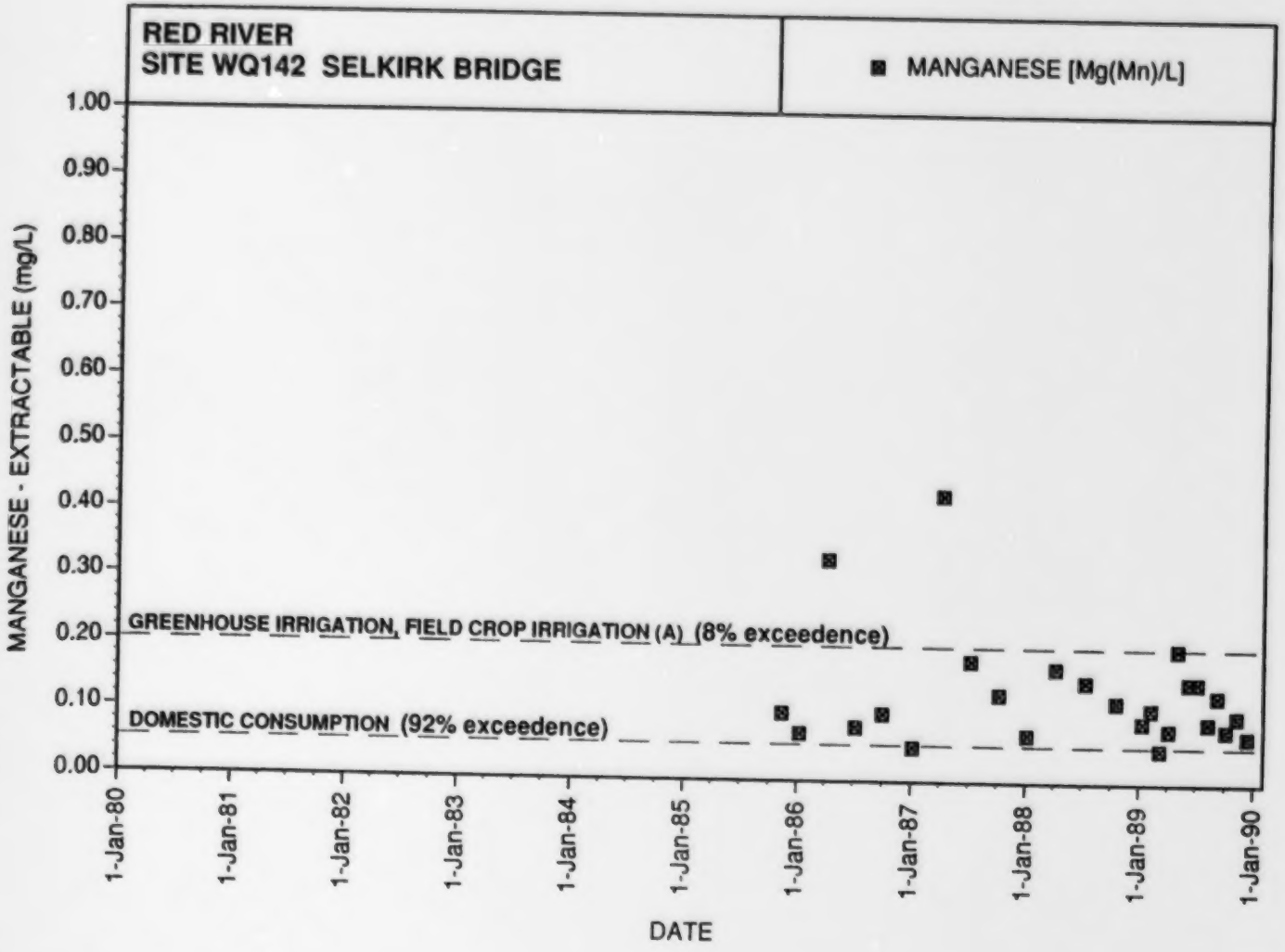


TABLE A86: Trend analysis and paired t-test results on manganese data.

TREND ANALYSIS RESULTS: MANGANESE. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.00	0.899 N/S	INCREASING	26
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.09	0.234 N/S	DECREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.01	0.385 N/S	INCREASING	58

PAIRED T-TEST RESULTS: MANGANESE DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.635 N/S	0.016	14
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.410 N/S	-0.017	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.329 N/S	0.035	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A133: Chloride concentrations in the Assiniboine River, at site WQ018 at Headingley.

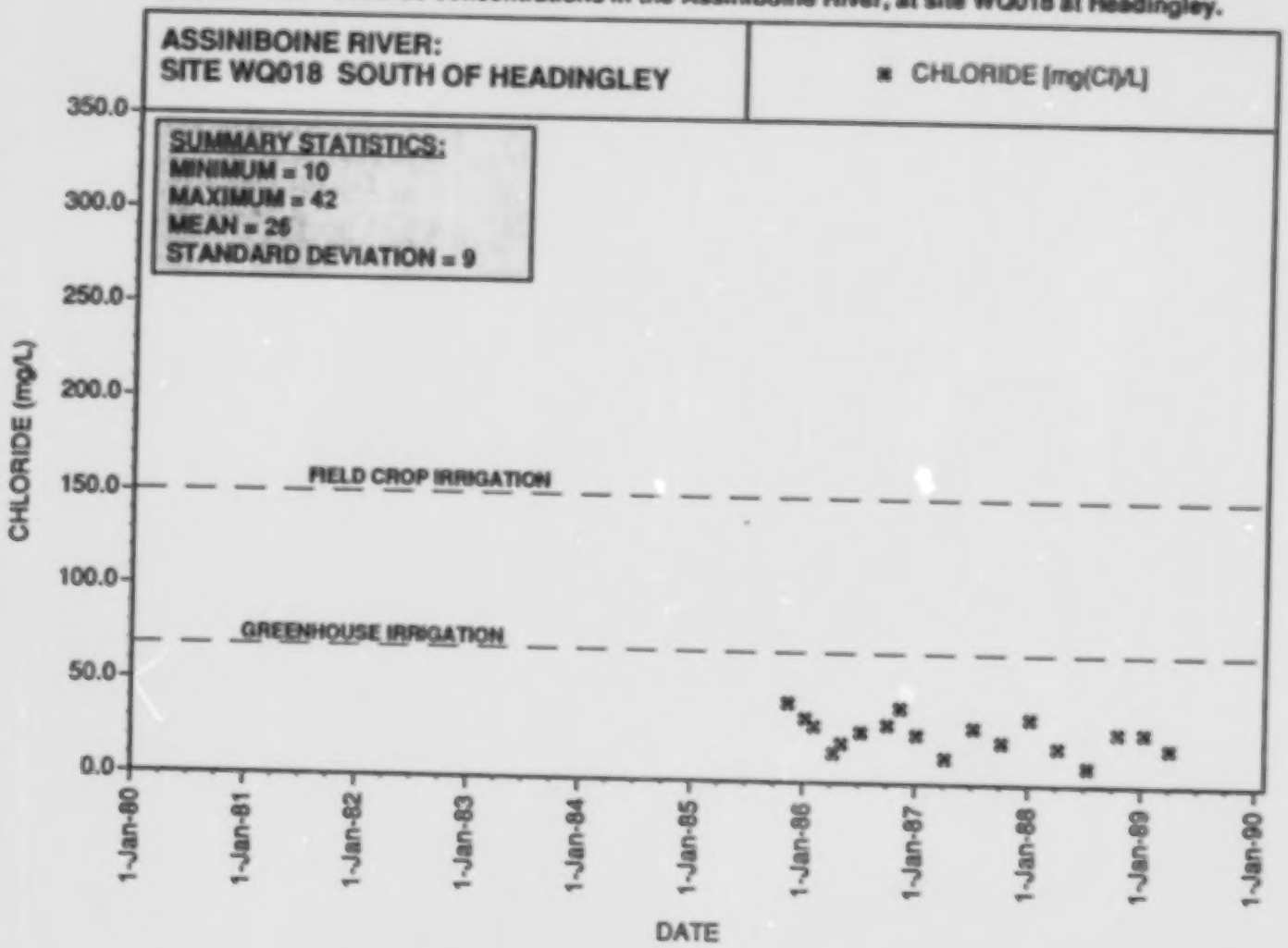


FIGURE A134: Chloride concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

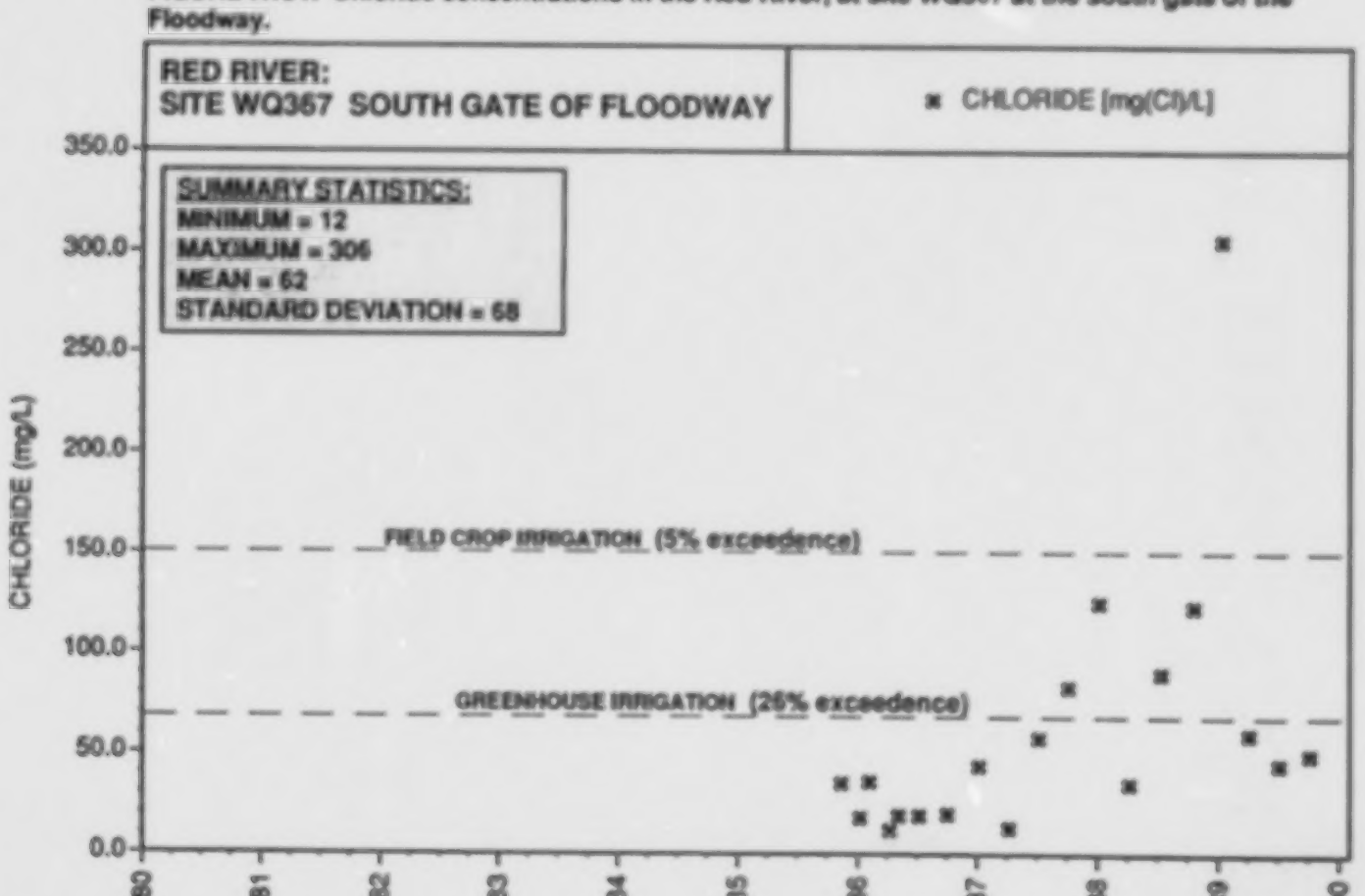


FIGURE A135: Chloride concentrations in the Red River, at site WQ142 at Selkirk.

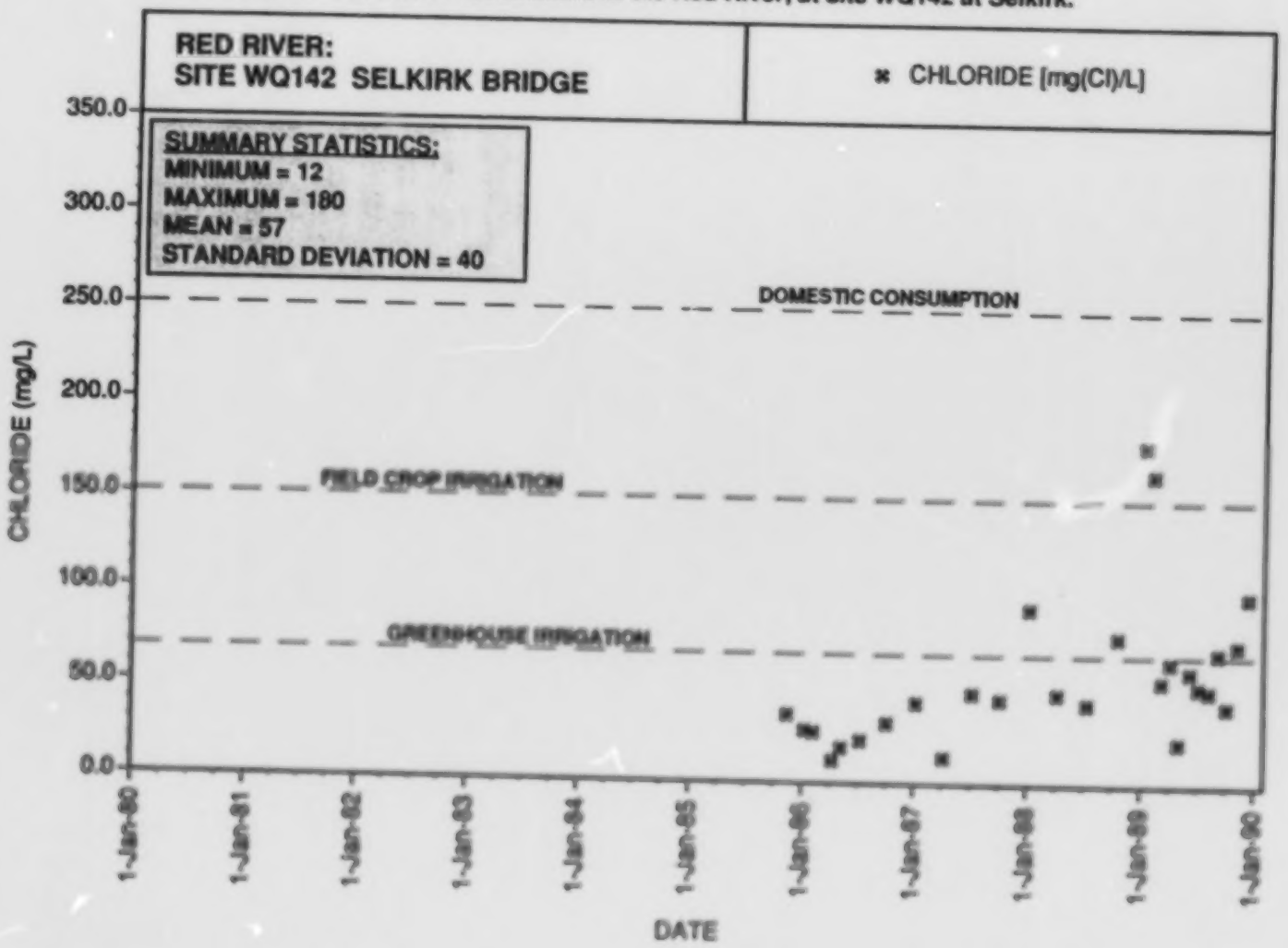


TABLE A87: Trend analysis and paired t-test results on chloride data.

TREND ANALYSIS RESULTS: CHLORIDE. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.09	0.003 **	DECREASING	103
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.25	0.030 *	INCREASING	19
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.05	0.010 *	INCREASING	132

PAIRED T-TEST RESULTS: CHLORIDE DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.025 *	-23.5	16
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.085 N/S	13.9	18
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.040 *	-38.9	16

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

FIGURE A136: Sodium concentrations in the Assiniboine River, at site WQ018 at Headingley.

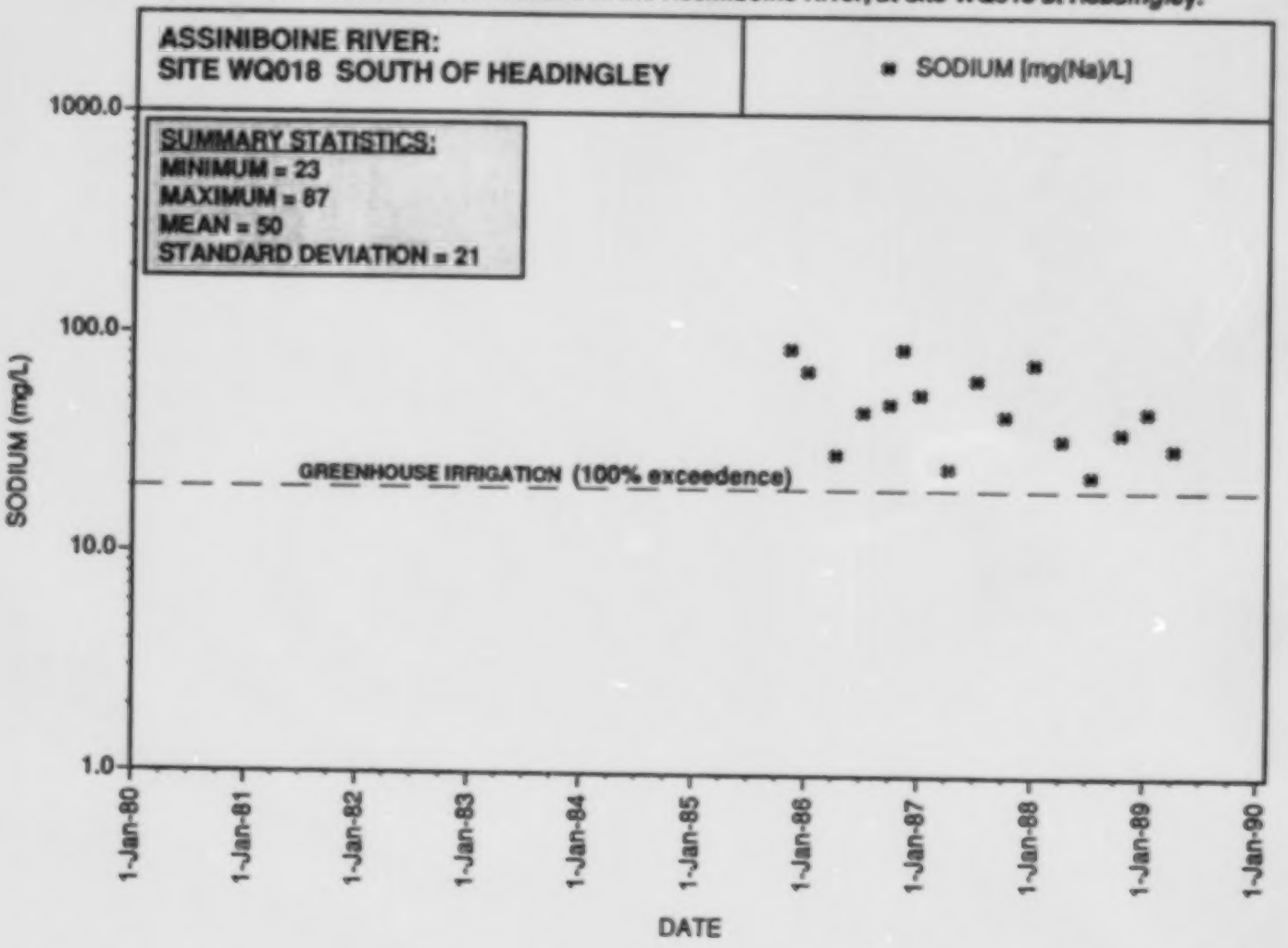


FIGURE A137: Sodium concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

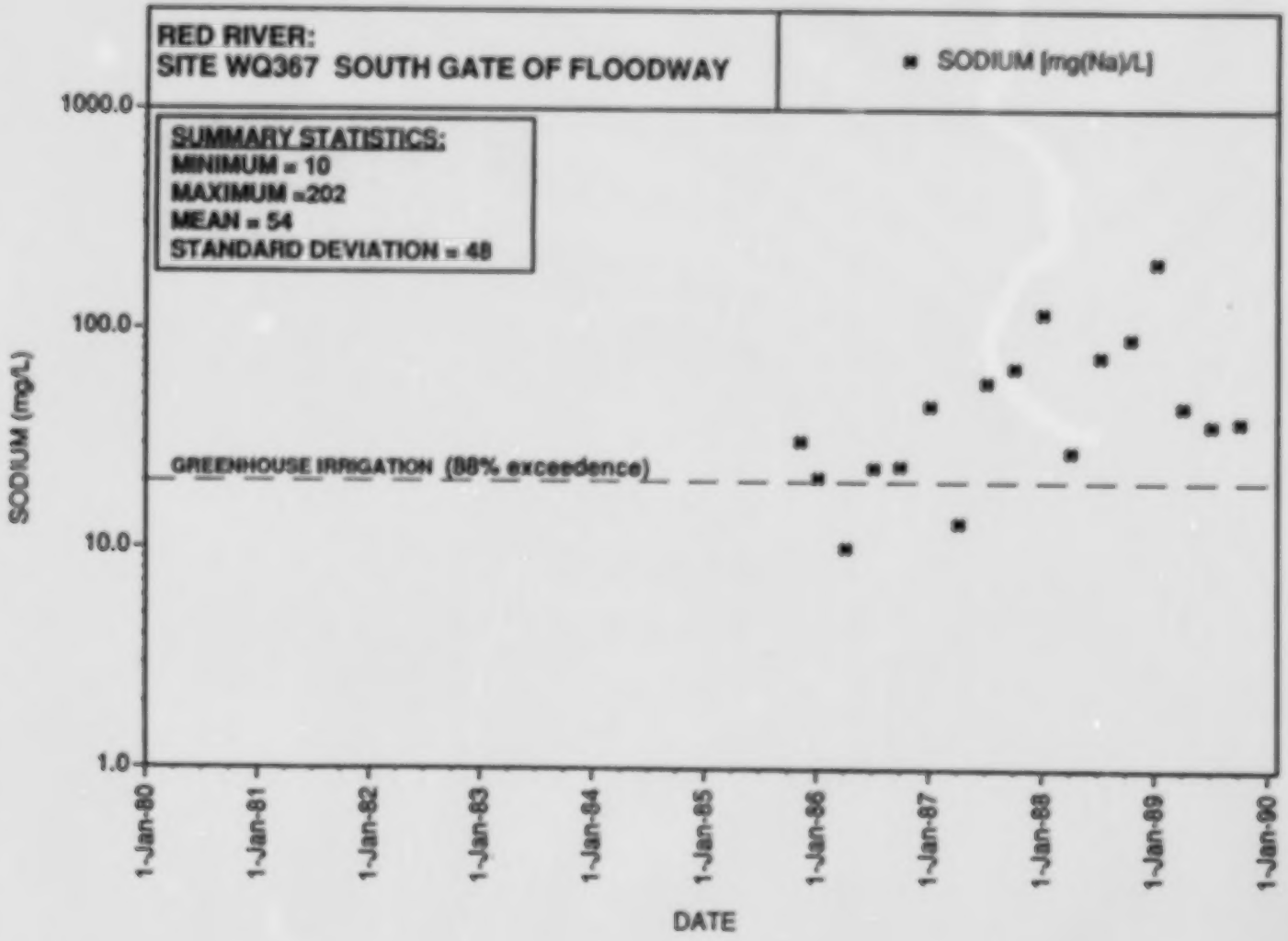


FIGURE A138: Sodium concentrations in the Red River, at site WQ142 at Selkirk.

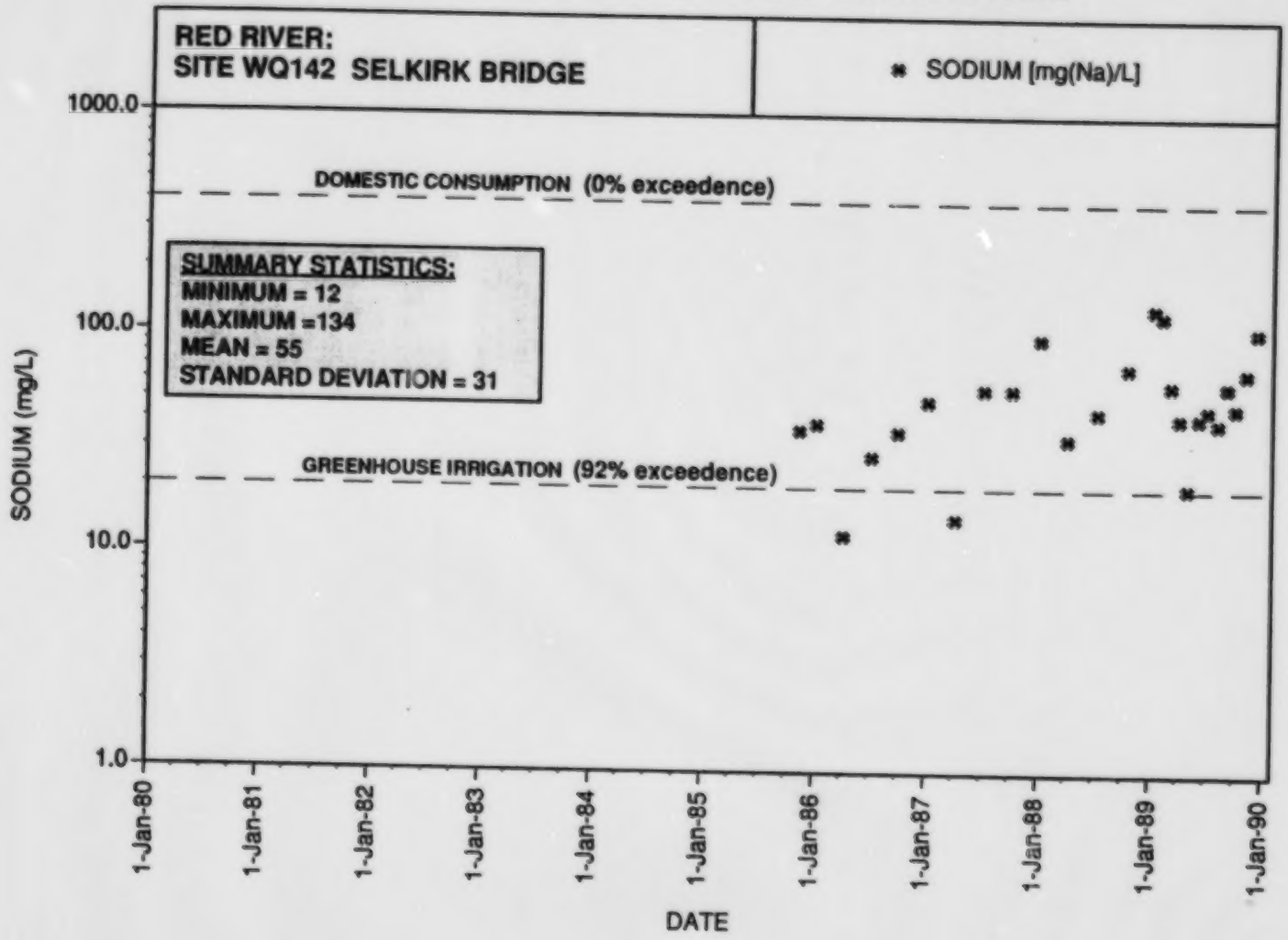


TABLE A88: Trend analysis and paired t-test results on sodium data.

TREND ANALYSIS RESULTS: SODIUM. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.12	0.006 **	DECREASING	60
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.20	0.070 N/S	INCREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.01	0.411 N/S	INCREASING	95

PAIRED T-TEST RESULTS: SODIUM DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.740 N/S	-2.81	14
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.399 N/S	4.37	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.515 N/S	-9.05	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A139: Sodium adsorption ratio in the Assiniboine River, at site WQ018 at Headingley.

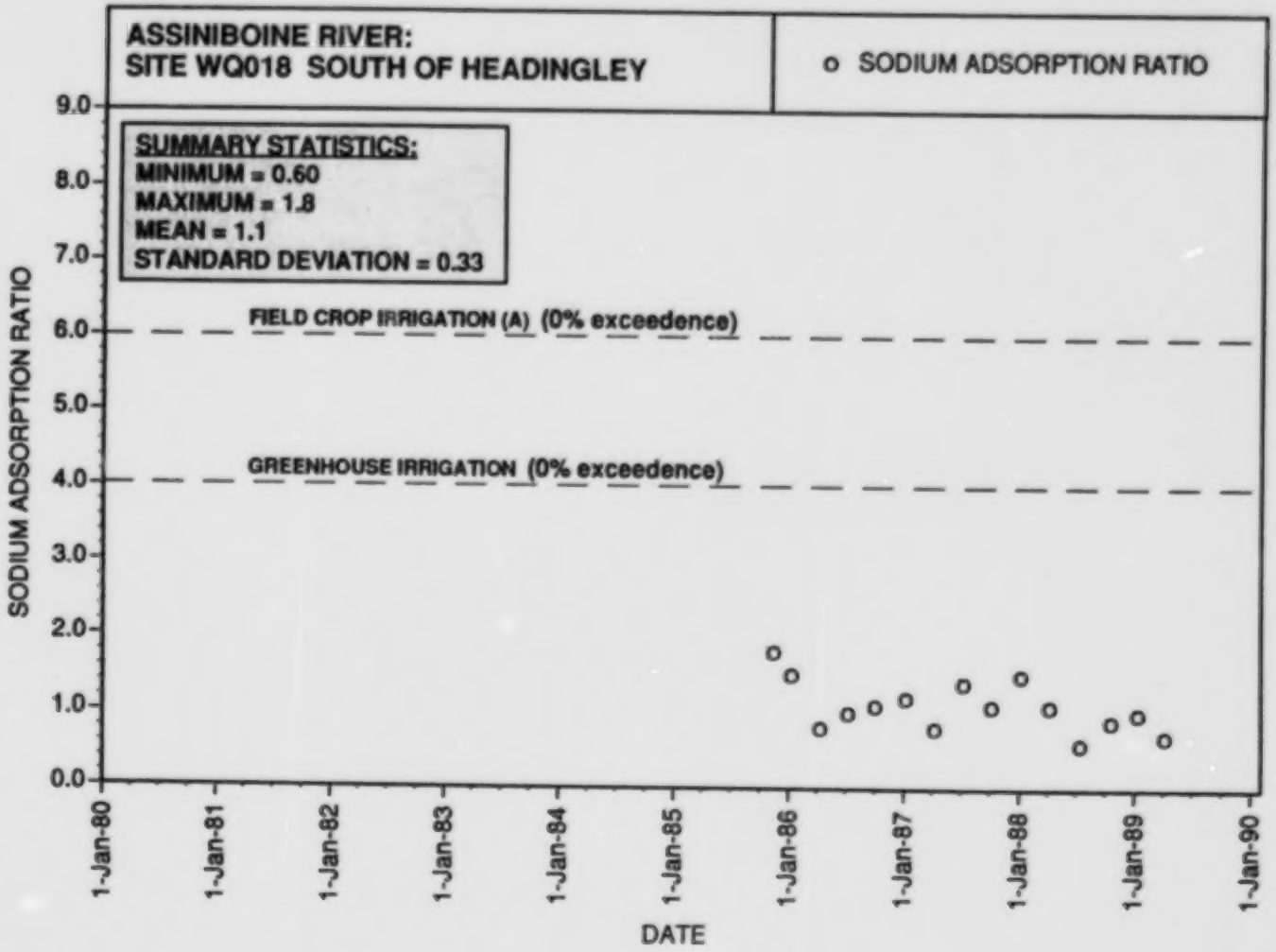


FIGURE A140: Sodium adsorption ratio in the Red River, at site WQ367 at the south gate of the Floodway.

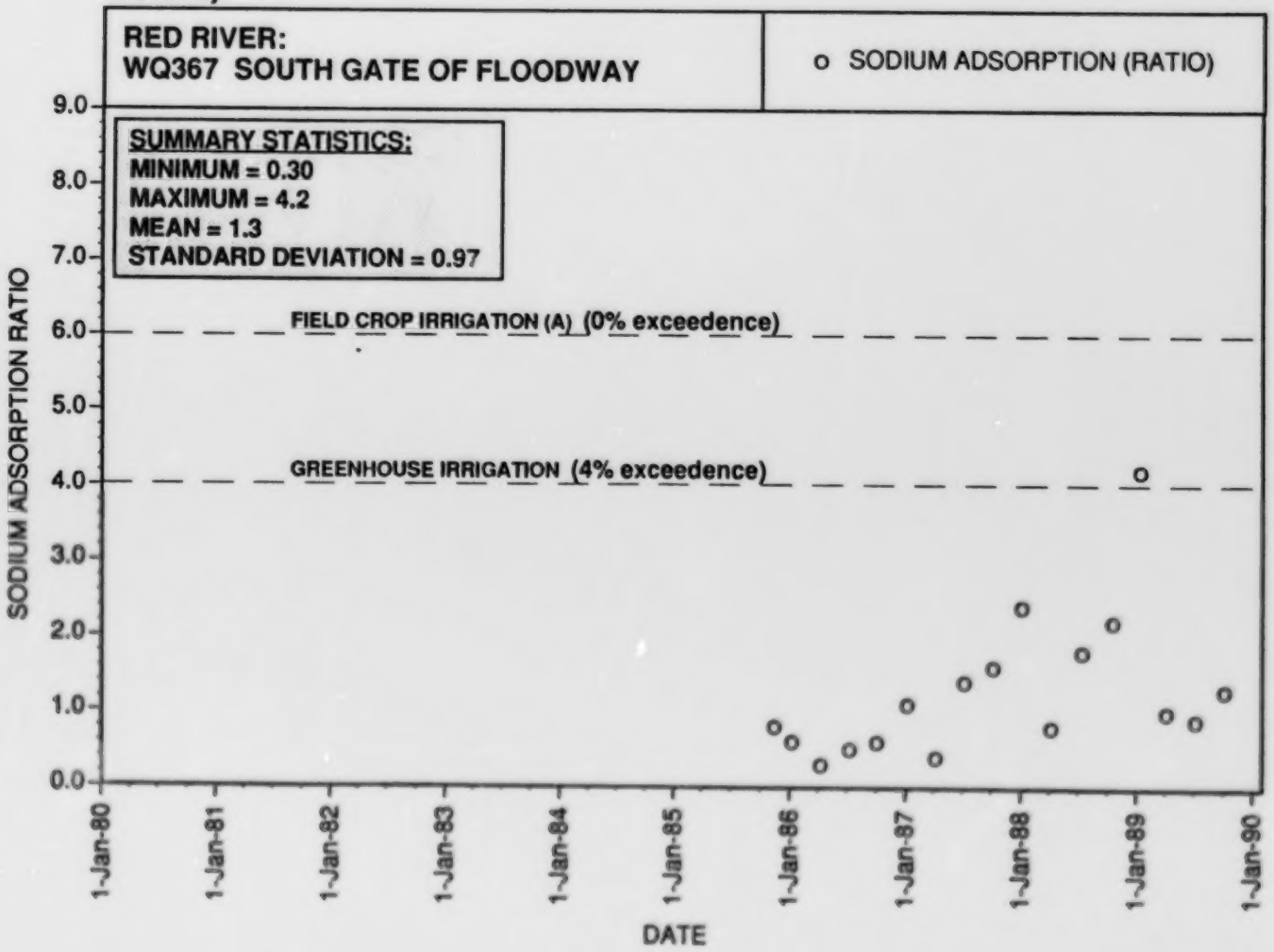


FIGURE A141: Sodium adsorption ratio in the Red River, at site WQ142 at Selkirk.

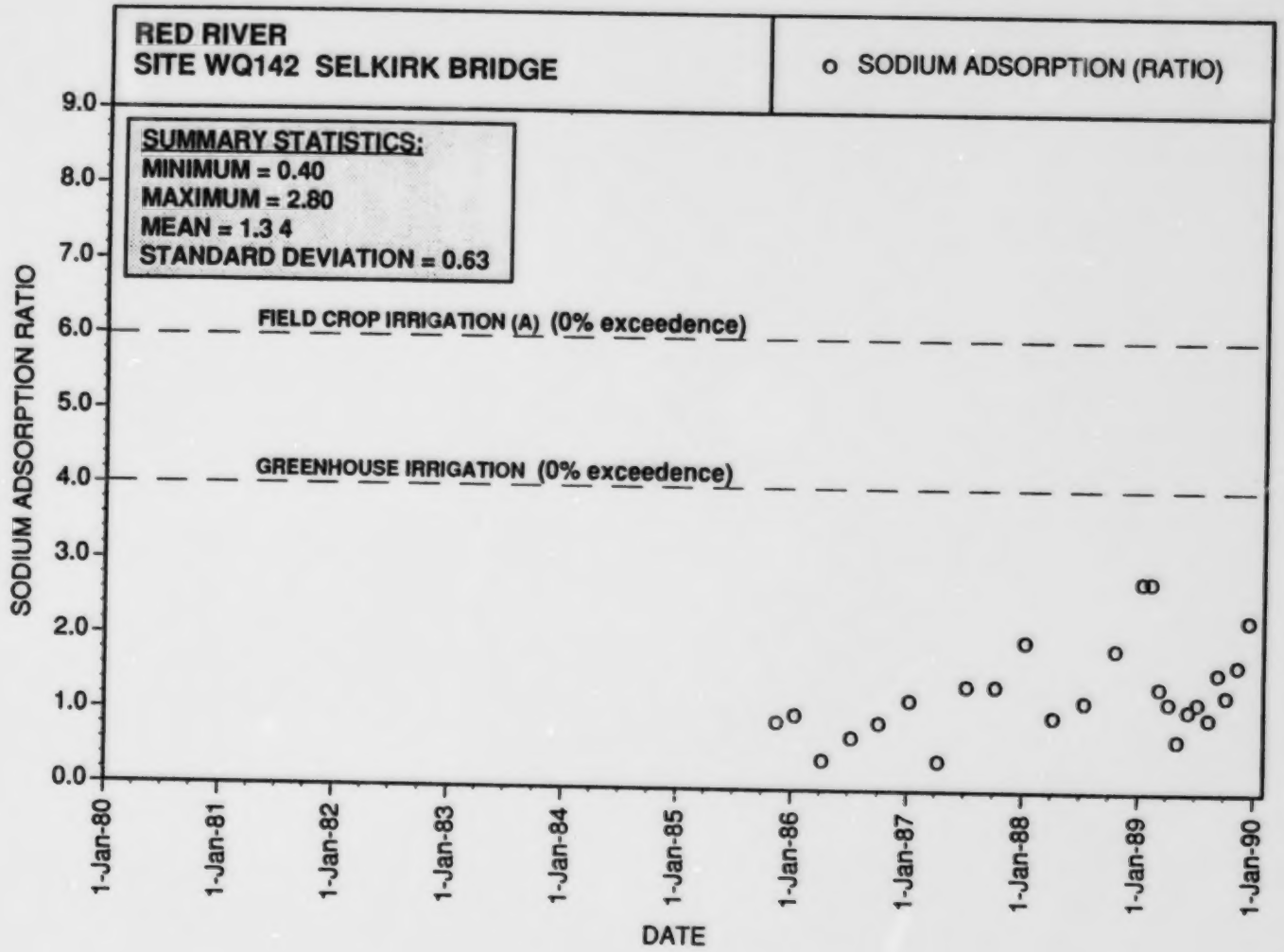


TABLE A89: Trend analysis and paired t-test results on sodium adsorption ratio data.

TREND ANALYSIS RESULTS: SODIUM ADSORPTION RATIO. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.30	0.000 **	DECREASING	41
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.56	0.000 **	INCREASING	28
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.06	0.041 *	DECREASING	77

PAIRED T-TEST RESULTS: SODIUM ADSORPTION RATIO DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (ratio)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.476 N/S	-0.086	21
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.581 N/S	0.042	23
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.456 N/S	-0.152	20

* indicates significance level of P<0.05

** indicates significance level of P<0.01

N/S indicates no significant trend/difference (P>0.05)

~ indicates insufficient data to perform analysis

FIGURE A142: Arsenic concentrations in the Assiniboine River, at site WQ018 at Headingley.

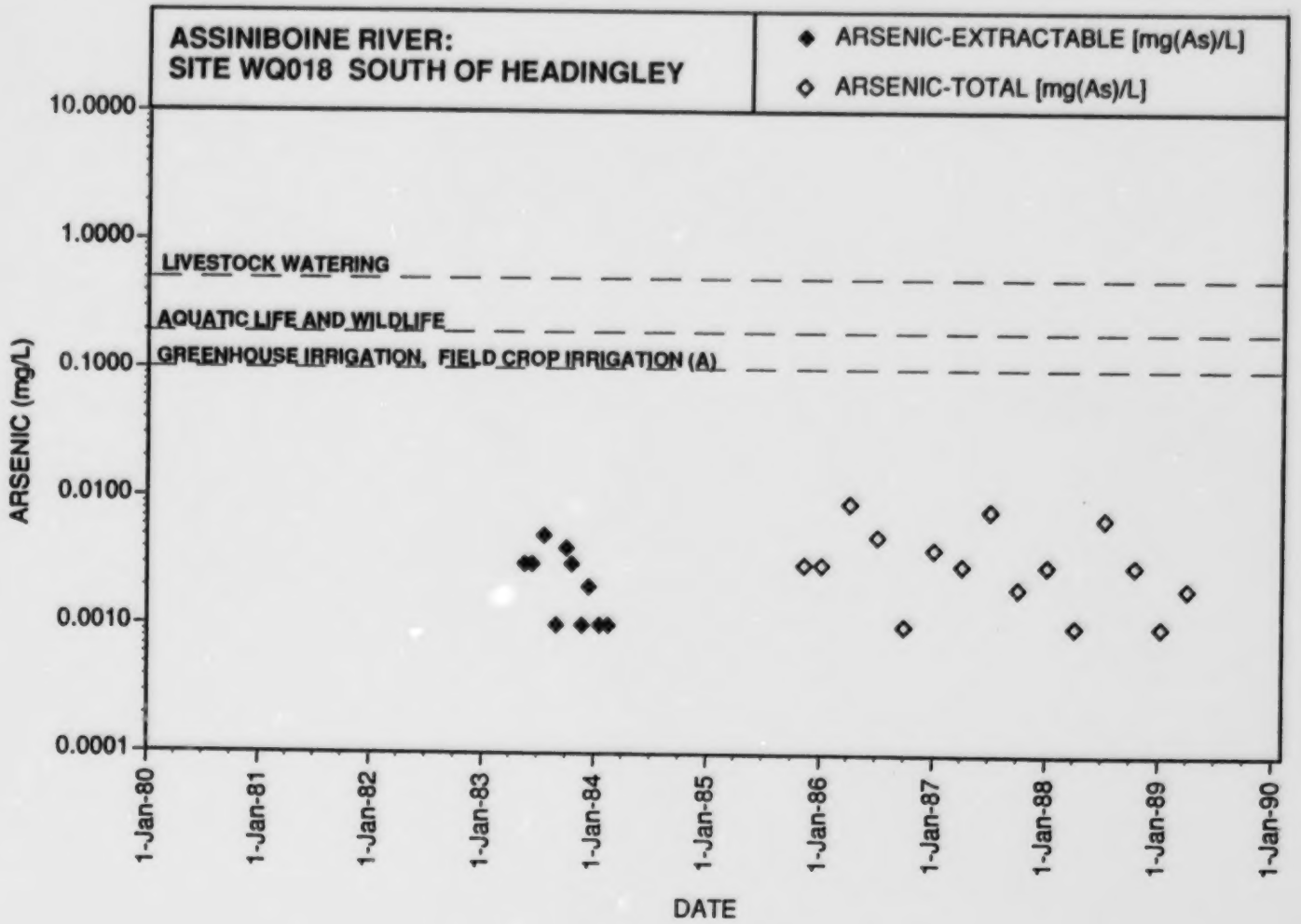


FIGURE A143: Arsenic concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

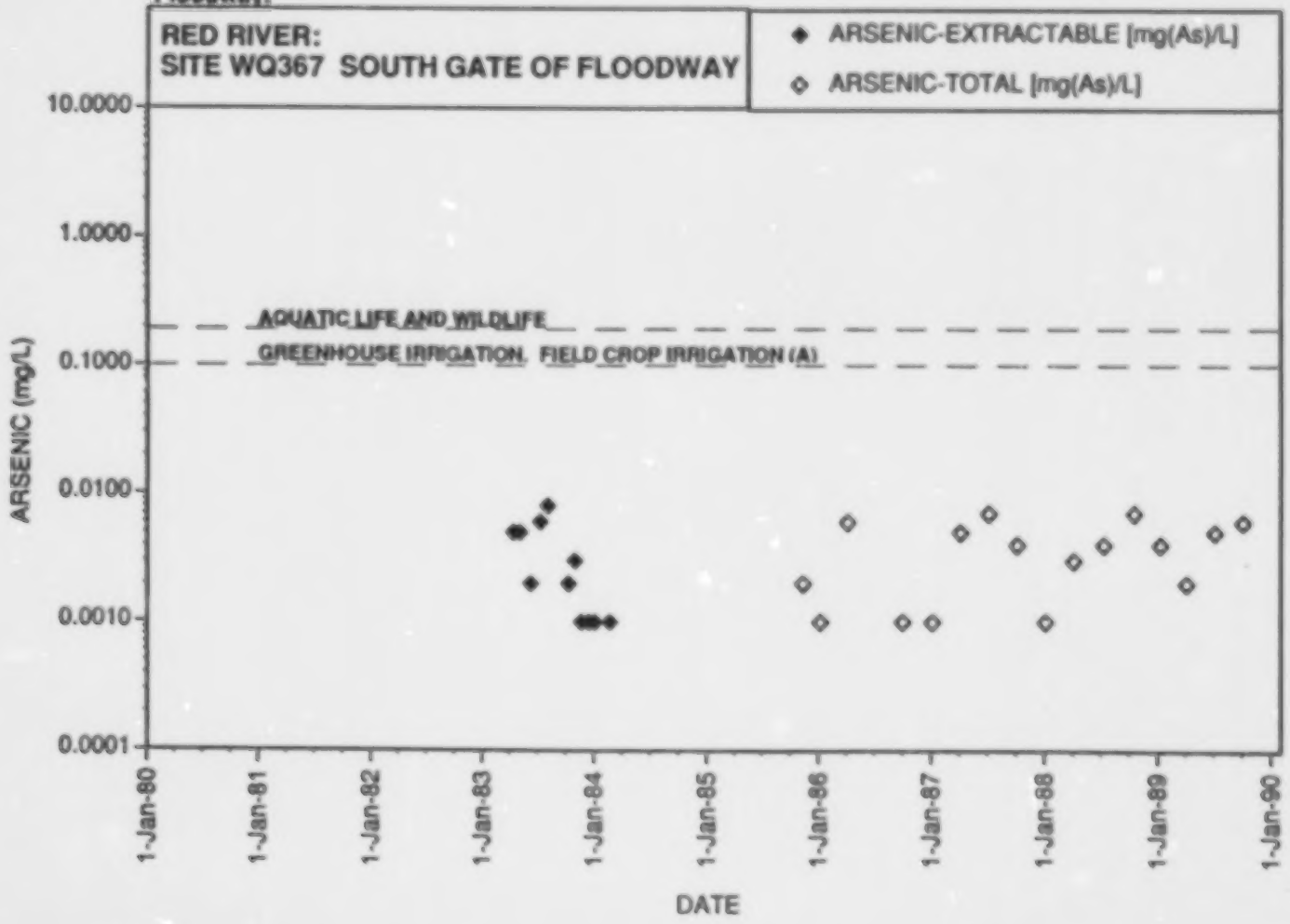


FIGURE A144: Arsenic concentrations in the Red River, at site WQ142 at Selkirk.

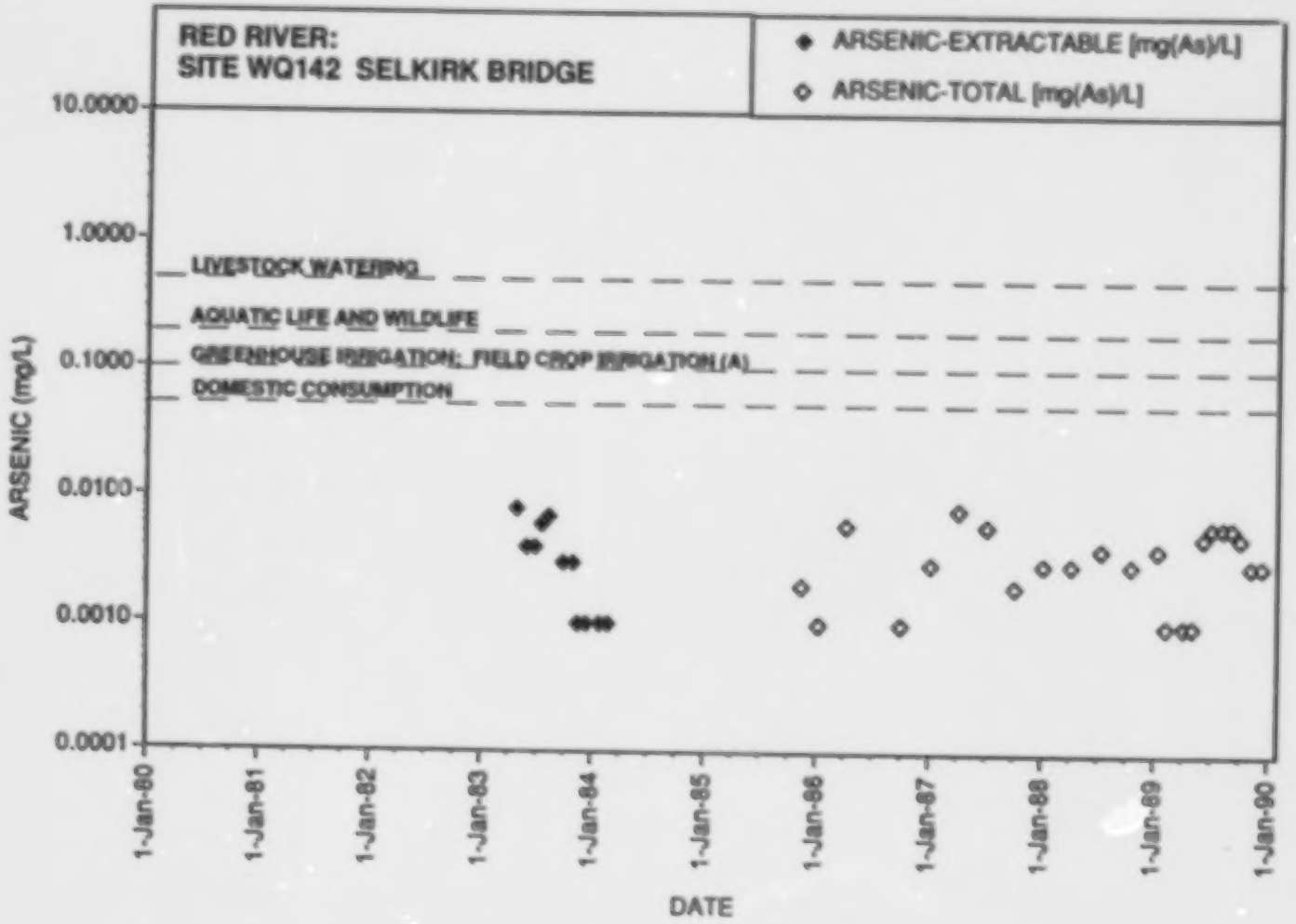


TABLE A90: Paired t-test results on arsenic data.

PAIRED T-TEST RESULTS: EXTRACTABLE ARSENIC DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1983-1984)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	1.000 N/S	<.0001	6
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.569 N/S	<-.0001	6
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.363 N/S	<.0001	5

PAIRED T-TEST RESULTS: TOTAL ARSENIC DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.728 N/S	<.0001	13
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.882 N/S	<-.0001	15
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.826 N/S	<.0001	13

* indicates significance level of P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend/difference (P>0.05)

FIGURE A145: Boron concentrations in the Assiniboine River, at site WQ018 at Headingley.

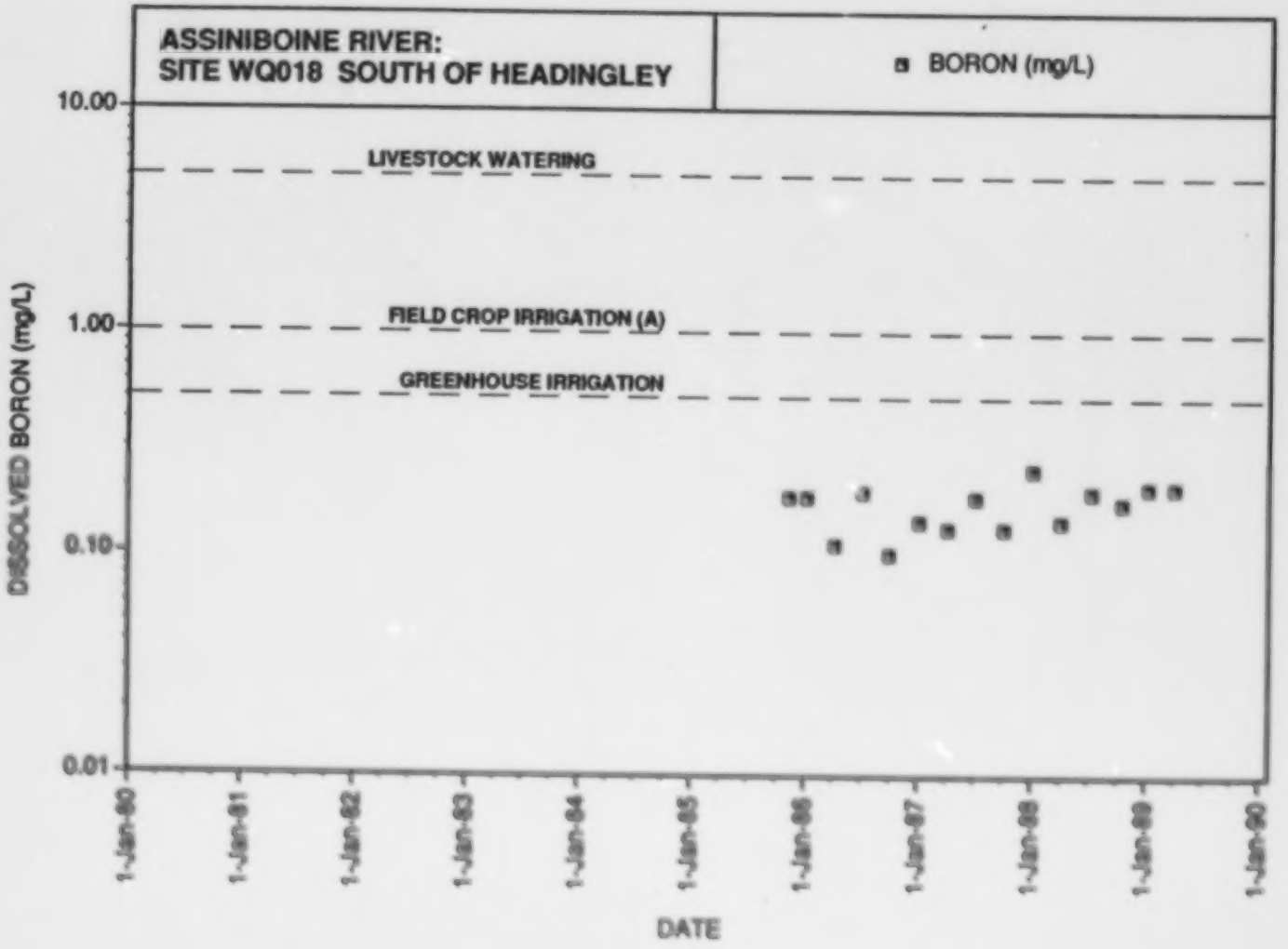


FIGURE A146: Boron concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

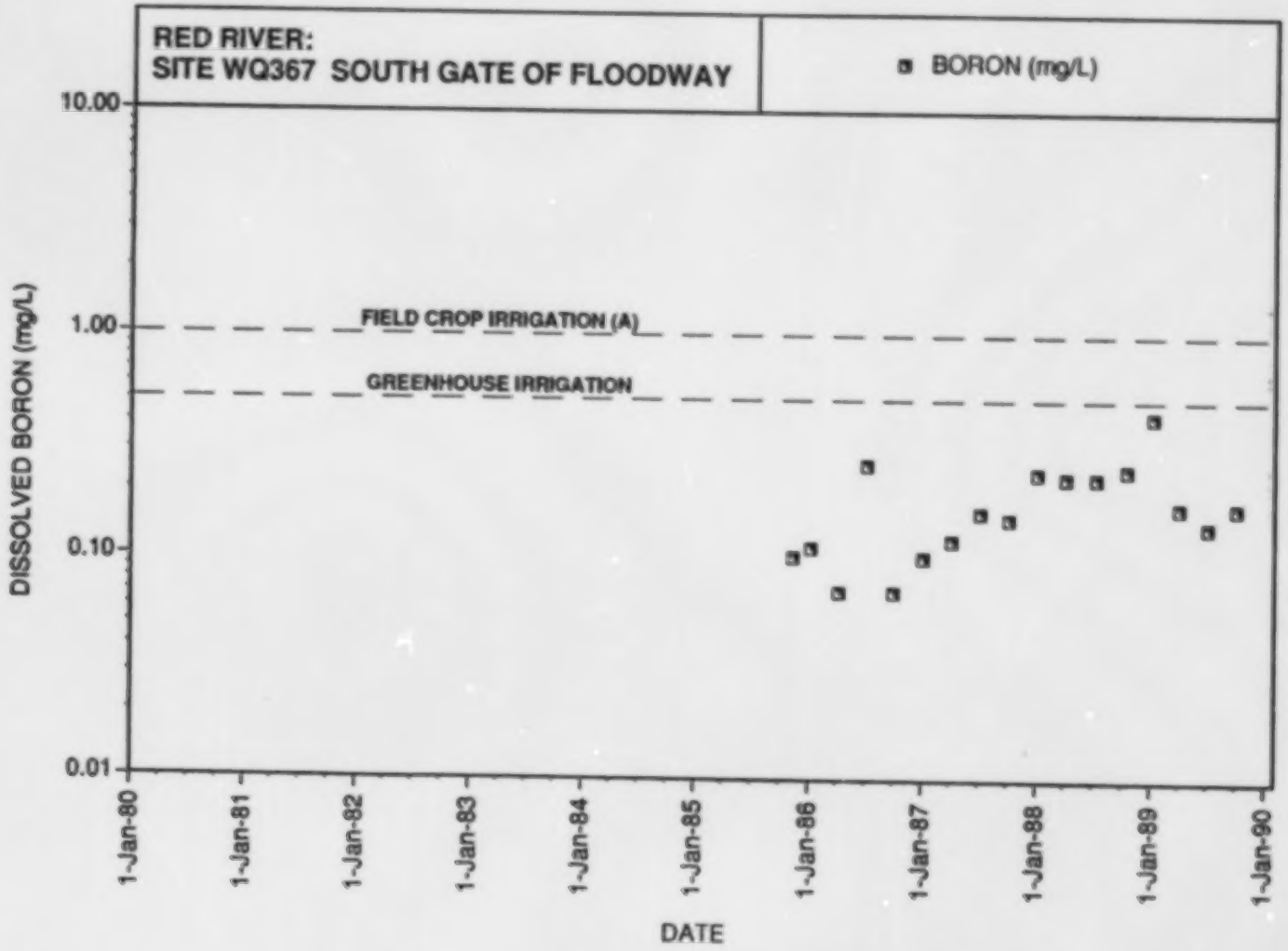


FIGURE A147: Boron concentrations in the Red River, at site WQ142 at Selkirk.

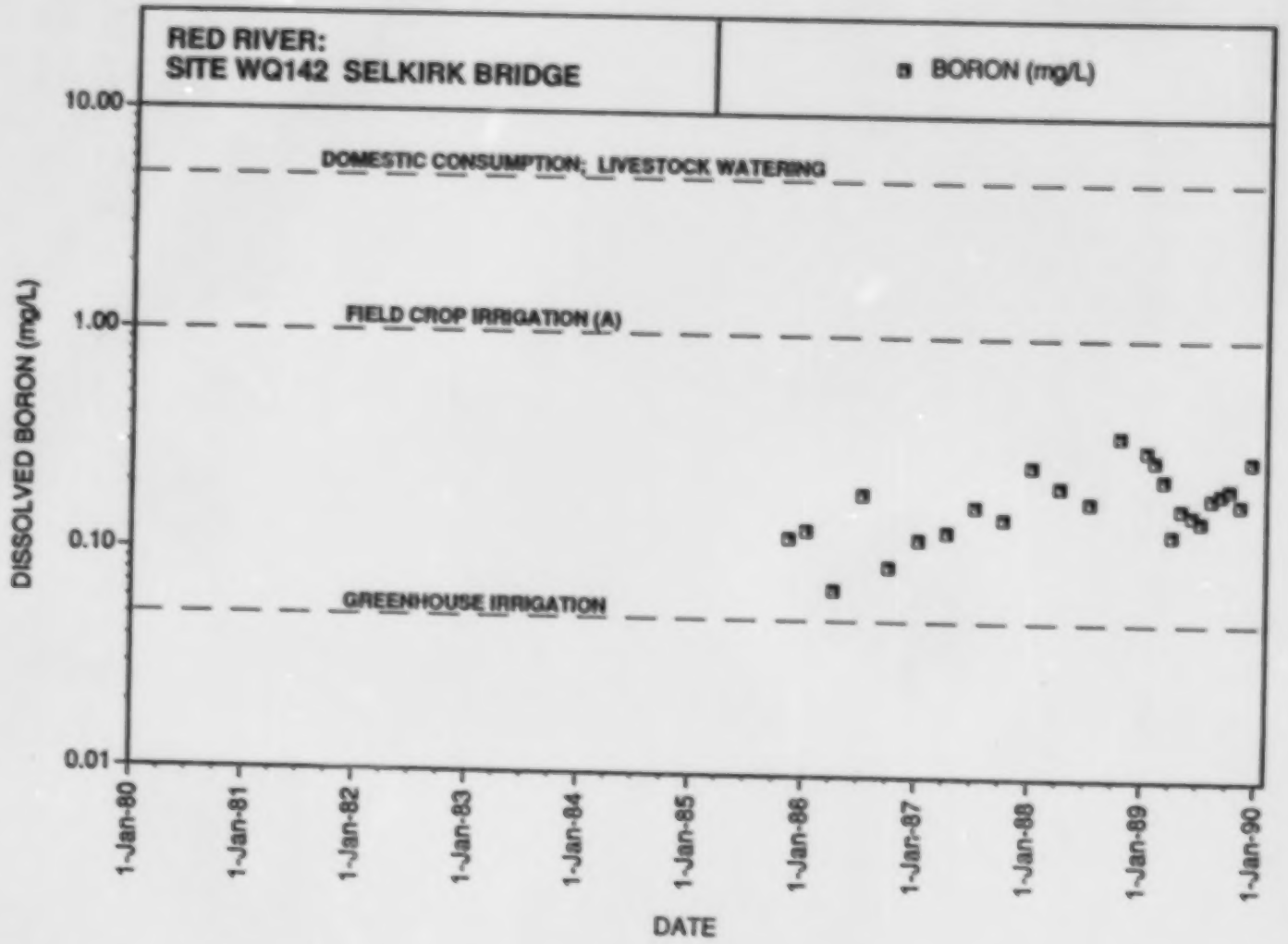


TABLE A91: Trend analysis and paired t-test results on boron data.

TREND ANALYSIS RESULTS: BORON. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.14	0.173 N/S	INCREASING	15
WQ451 HEADINGLEY	-	-	-	-
WQ452 WEST PERIMETER	-	-	-	-
WQ453 MAIN STREET BRIDGE	-	-	-	-
RED RIVER SITES:				
WQ067 SOUTH GATE OF FLOODWAY	0.25	0.041 *	INCREASING	17
WQ445 FLOODWAY CONTROL	-	-	-	-
WQ576 FORT GARY BRIDGE	-	-	-	-
WQ447 NORWOOD BRIDGE	-	-	-	-
WQ448 REDWOOD BRIDGE	-	-	-	-
WQ449 NORTH PERIMETER	-	-	-	-
WQ450 LOCKPORT BRIDGE	-	-	-	-
WQ142 SELKIRK	0.28	0.007 **	INCREASING	25

PAIRED T-TEST RESULTS: BORON DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.609 N/S	-0.009	14
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.924 N/S	0.001	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.506 N/S	-0.014	14

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
- indicates insufficient data to perform analysis

FIGURE A148: Iron concentrations in the Assiniboine River, at site WQ018 at Headingley.

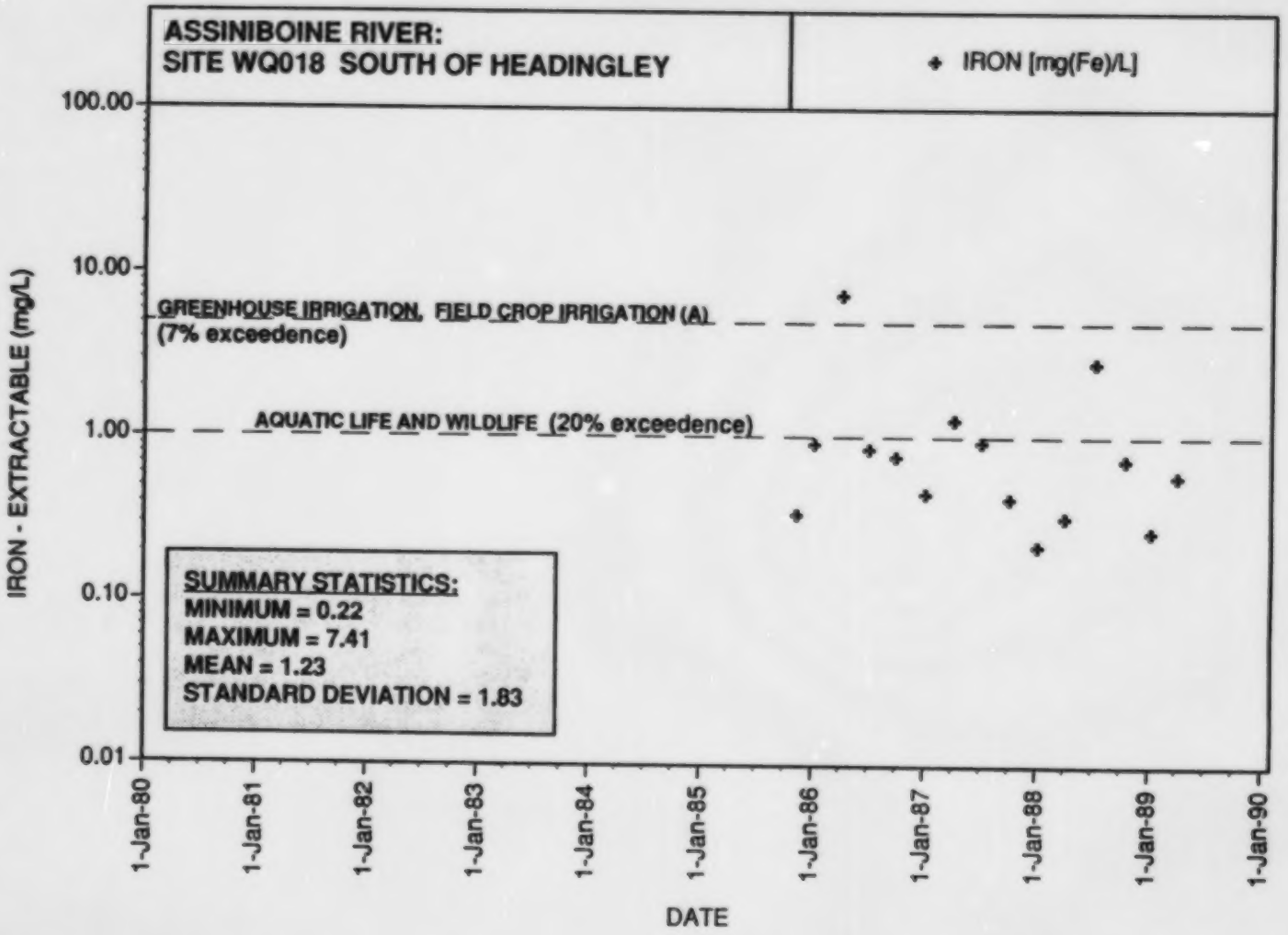


FIGURE A149: Iron concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

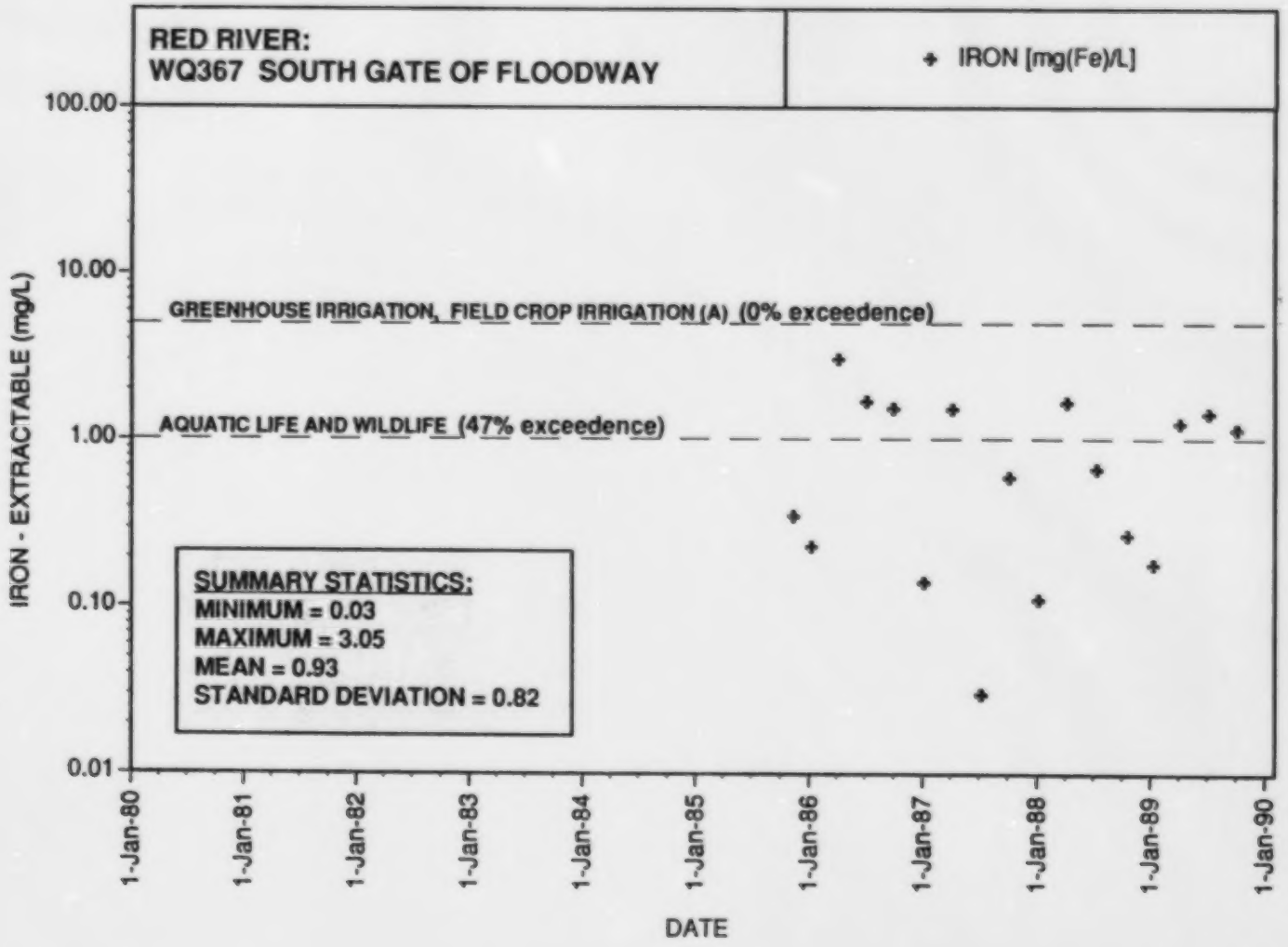


FIGURE A150: Iron concentrations in the Red River, at site WQ142 at Selkirk.

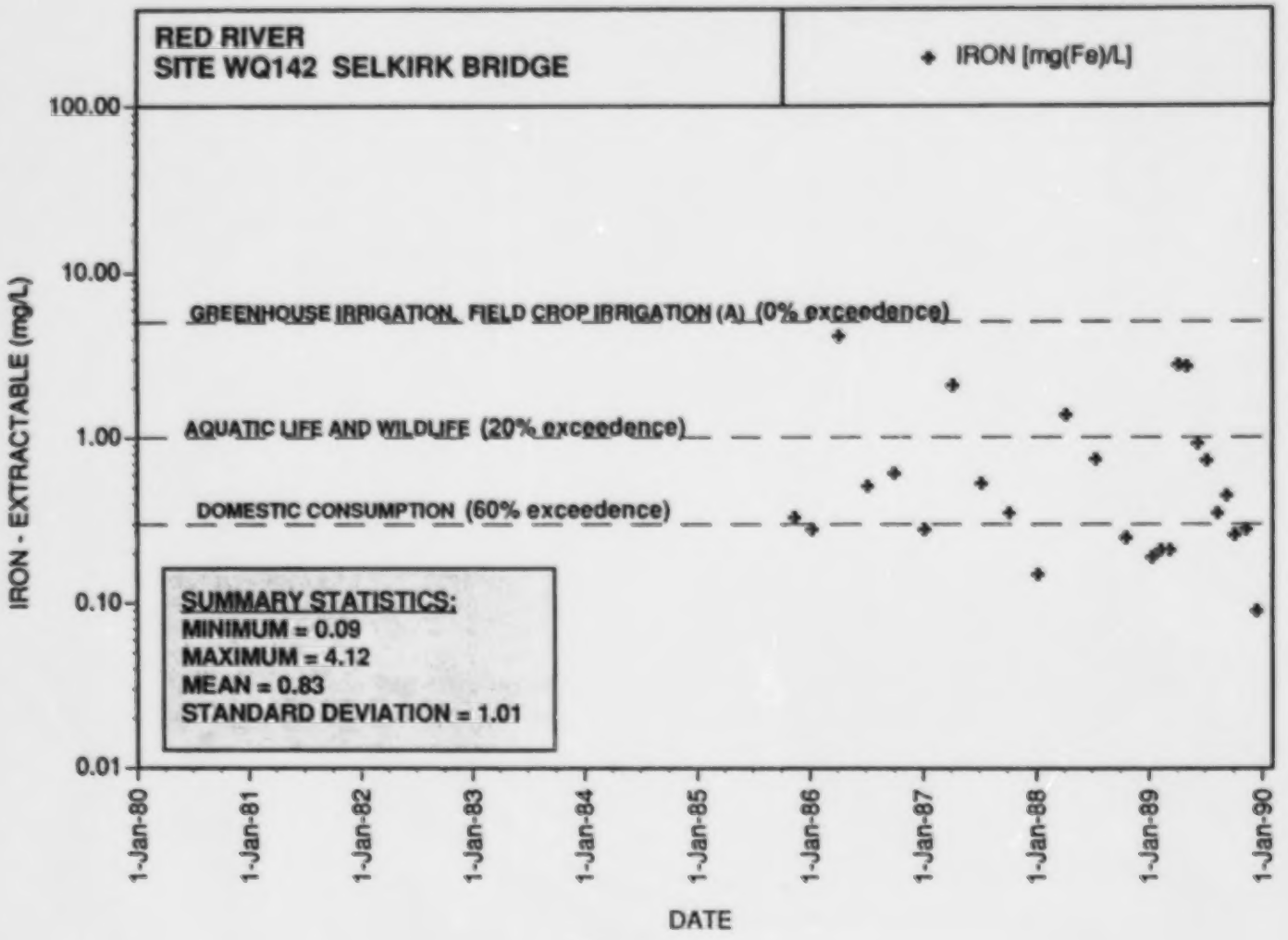


TABLE A92: Trend analysis and paired t-test results on iron data.

TREND ANALYSIS RESULTS: IRON. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:	0.07	0.178 N/S	INCREASING	28
WQ018 SOUTH OF HEADINGLEY	~	~	~	~
WQ451 HEADINGLEY	~	~	~	~
WQ452 WEST PERIMETER	~	~	~	~
WQ453 MAIN STREET BRIDGE	~	~	~	~
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.01	0.682 N/S	DECREASING	17
WQ445 FLOODWAY CONTROL	~	~	~	~
WQ576 FORT GARY BRIDGE	~	~	~	~
WQ447 NORWOOD BRIDGE	~	~	~	~
WQ448 REDWOOD BRIDGE	~	~	~	~
WQ449 NORTH PERIMETER	~	~	~	~
WQ450 LOCKPORT BRIDGE	~	~	~	~
WQ142 SELKIRK	0.09	0.025 *	INCREASING	58

PAIRED T-TEST RESULTS: IRON DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1985-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SOUTH HEADINGLEY	0.422 N/S	0.265	14
SOUTH FLOODWAY vs SELKIRK	SOUTH FLOODWAY	0.884 N/S	0.025	16
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH HEADINGLEY	0.358 N/S	0.343	14

* indicates significance level of $P<0.05$

** indicates significance level of $P<0.01$

N/S indicates no significant trend/difference ($P>0.05$)

~ indicates insufficient data to perform analysis

FIGURE A151: Copper concentrations in the Assiniboine River, at site WQ018 at Headingley.

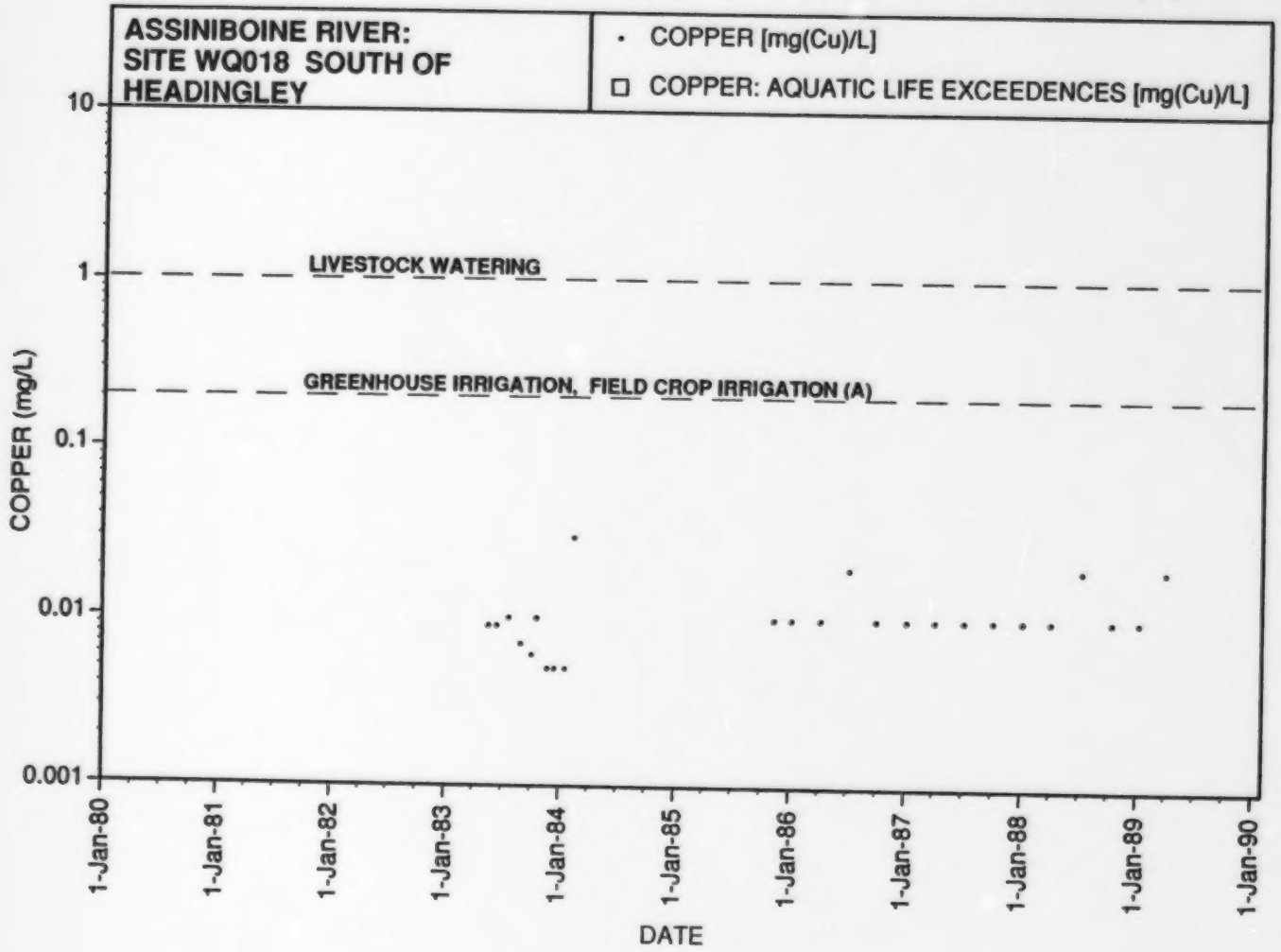


FIGURE A152: Copper concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

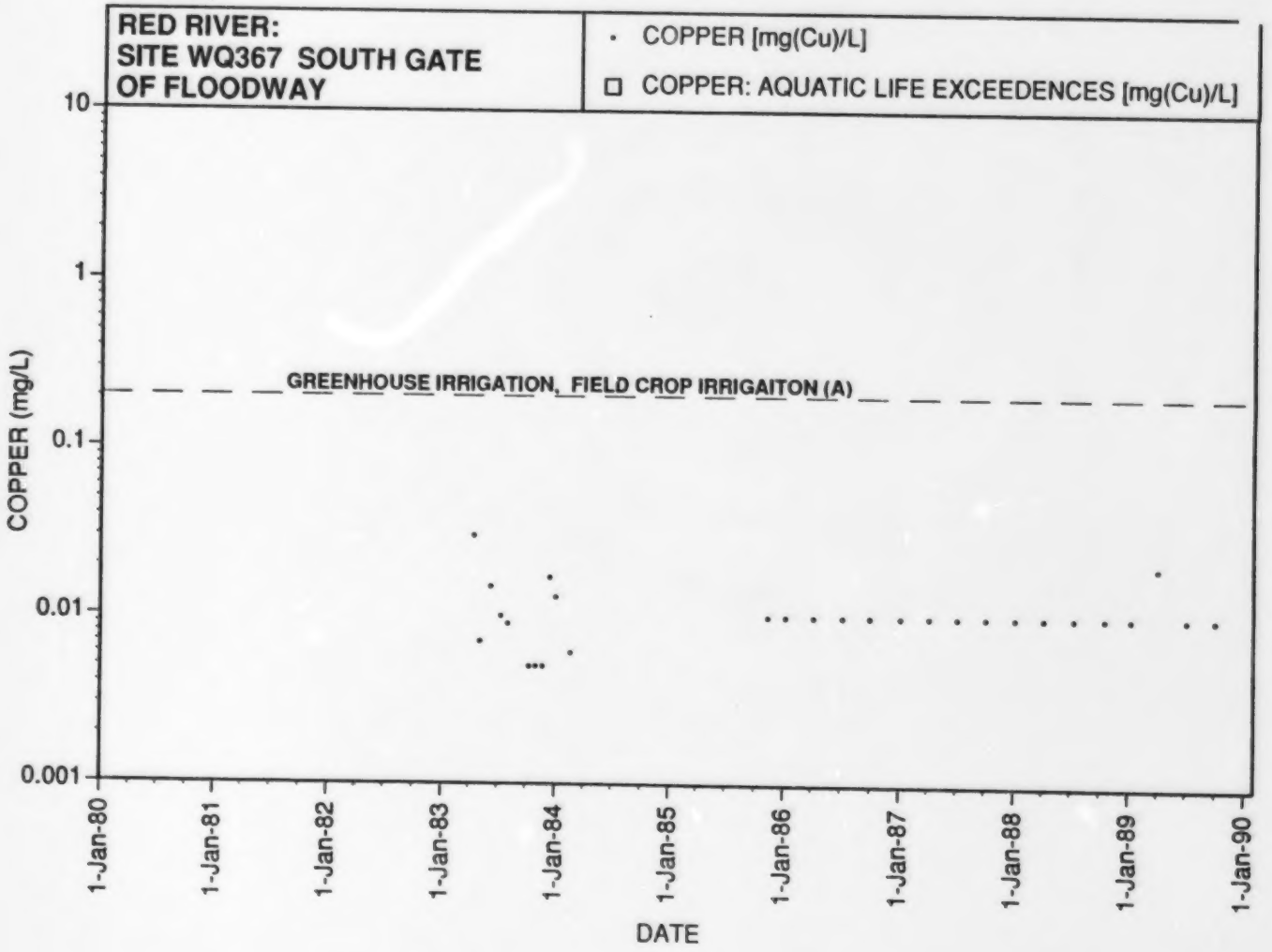


FIGURE A153: Copper concentrations in the Red River, at site WQ142 at Selkirk.

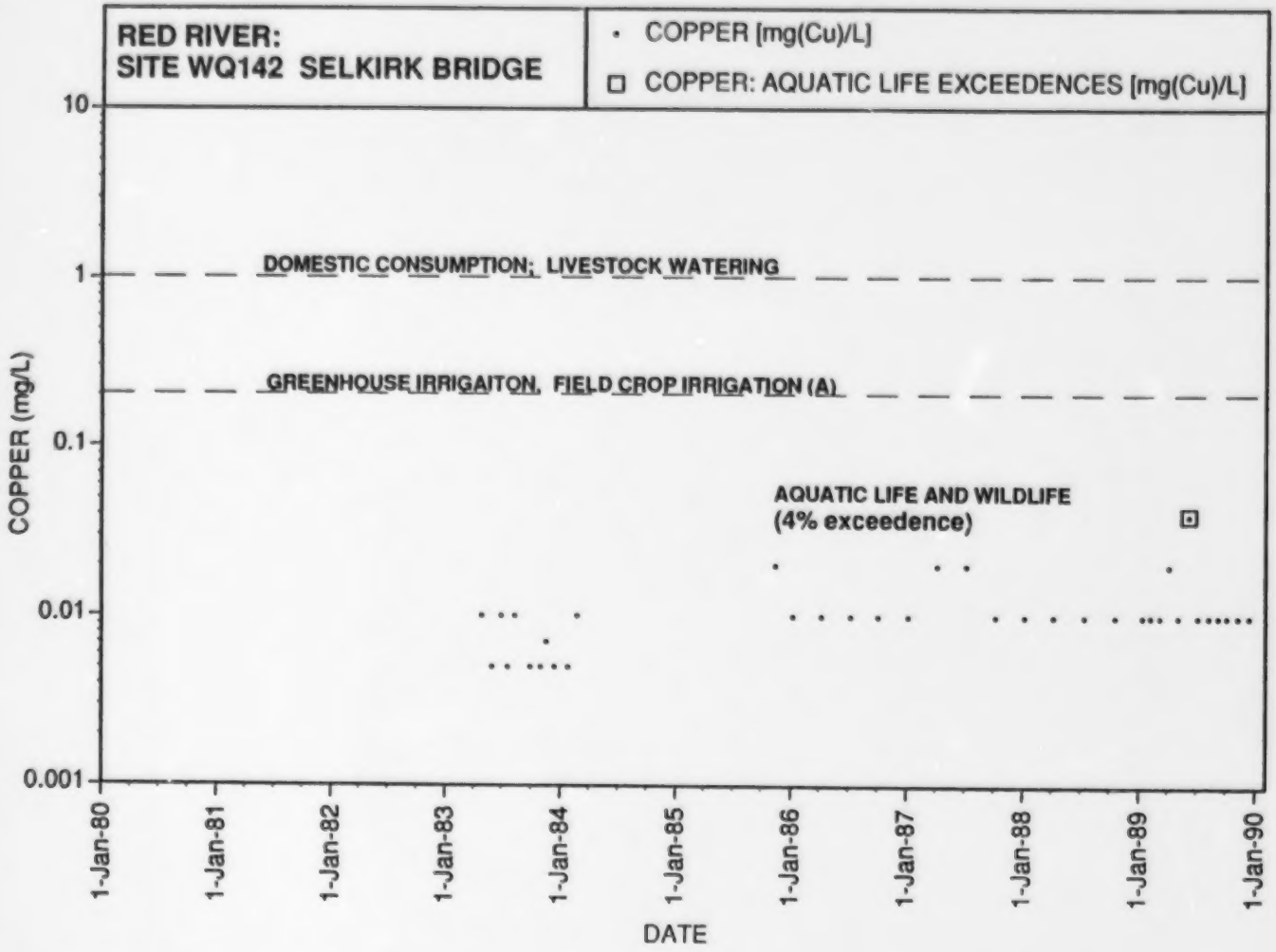


FIGURE A154: Lead concentrations in the Assiniboine River, at site WQ018 at Headingley.

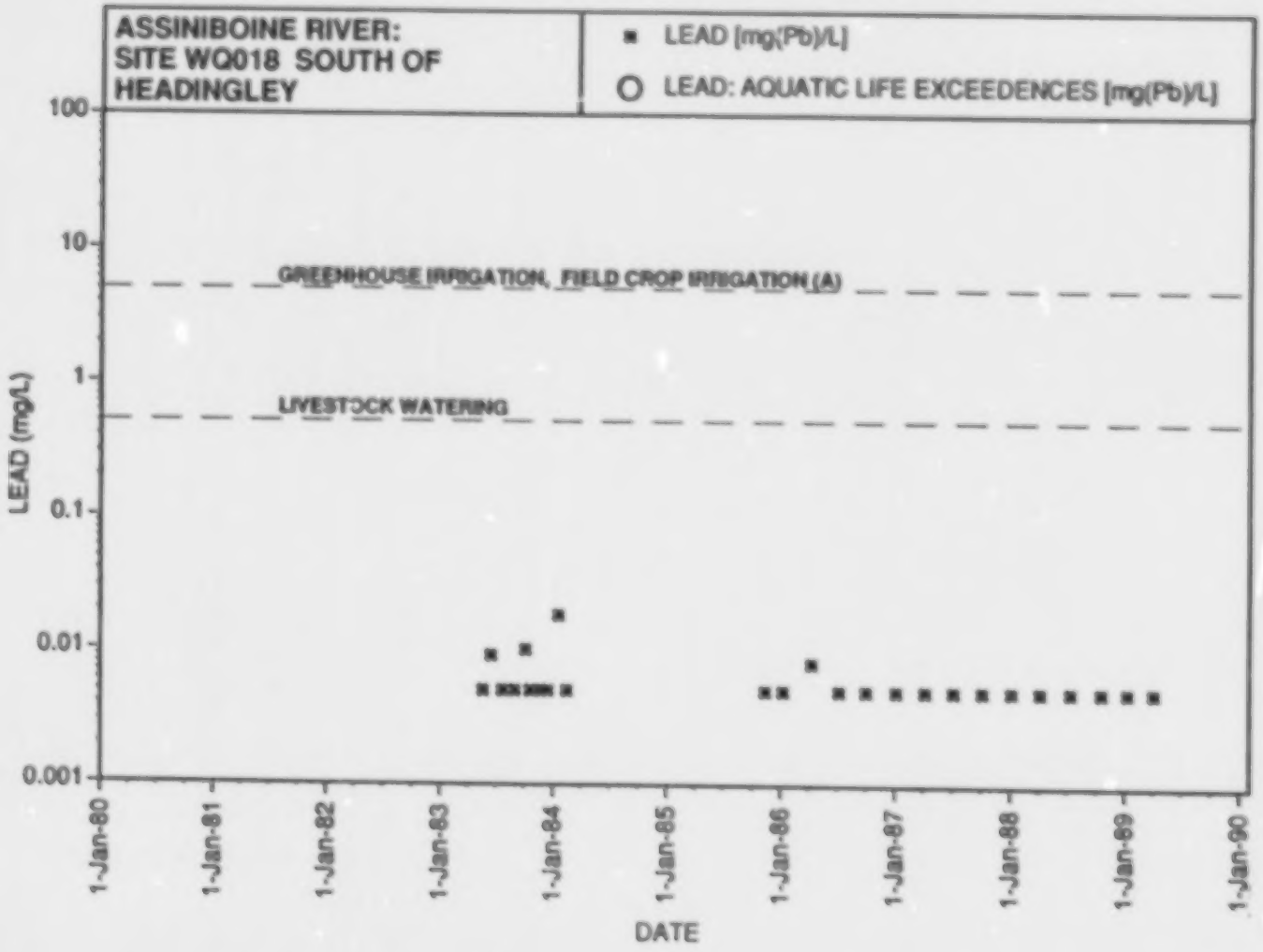


FIGURE A155: Lead concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

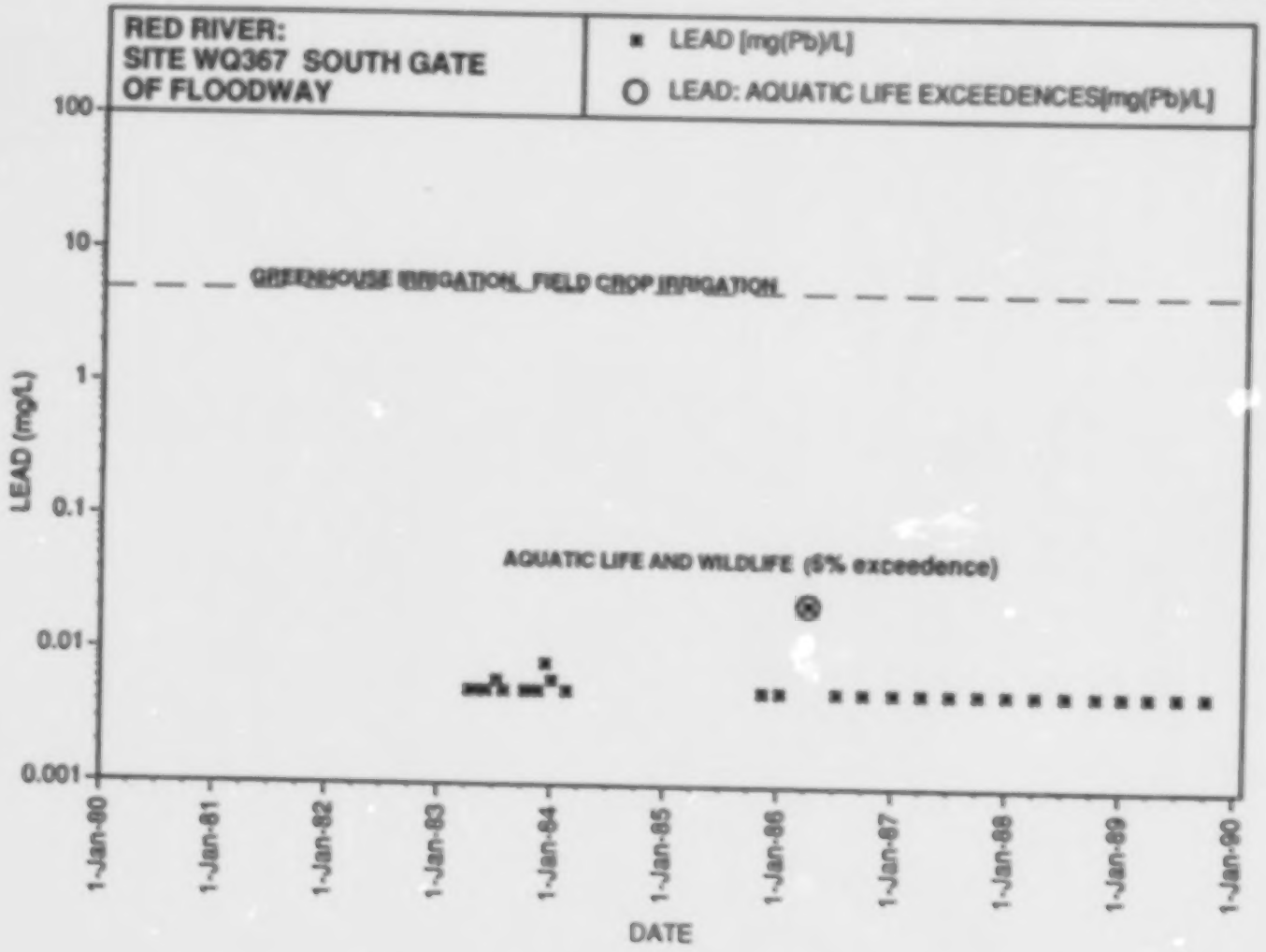


FIGURE A156: Lead concentrations in the Red River, at site WQ142 at Selkirk.

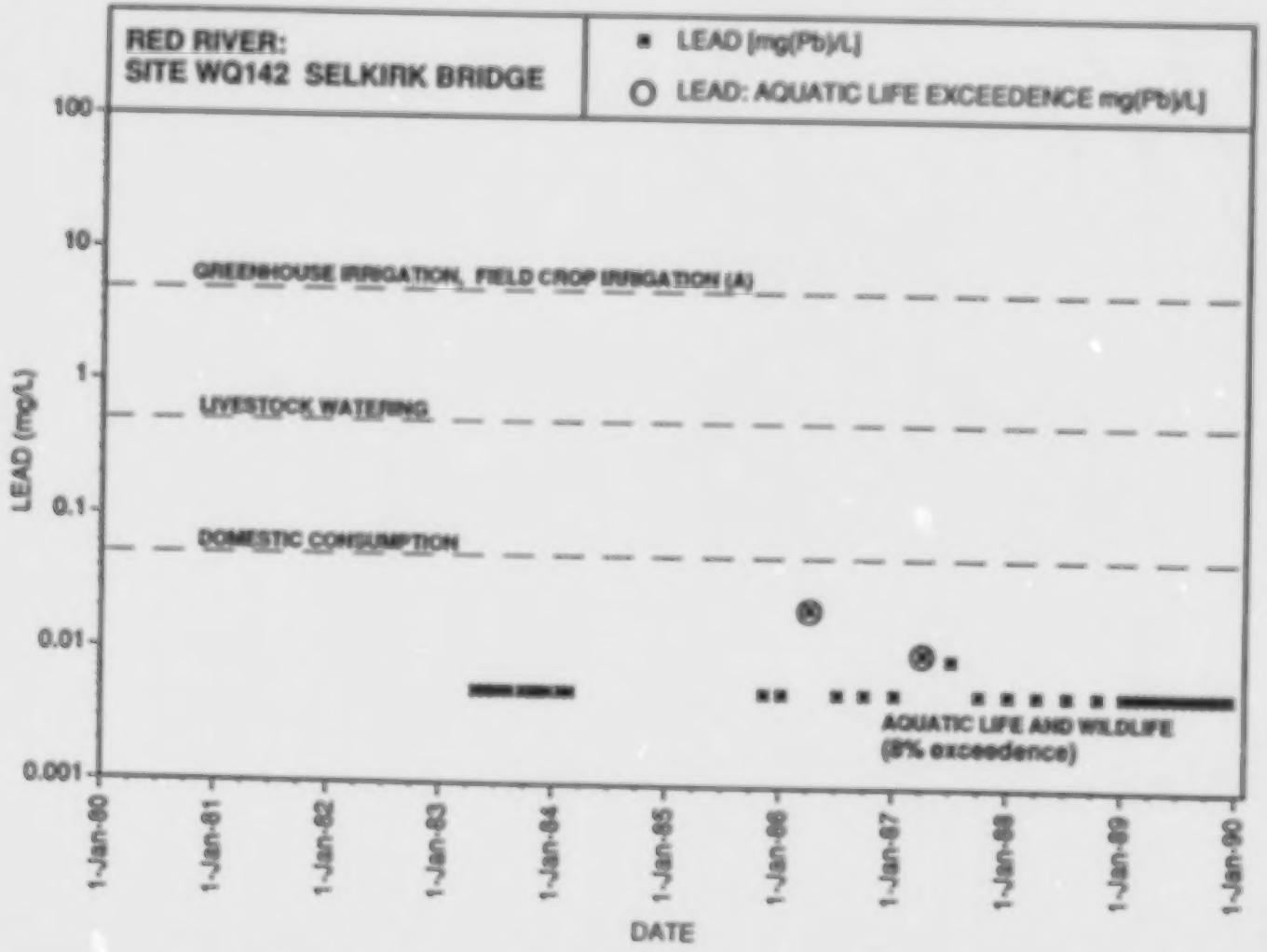


FIGURE 157: Nickle concentrations in the Assiniboine River at site WQ018 at Headingley.

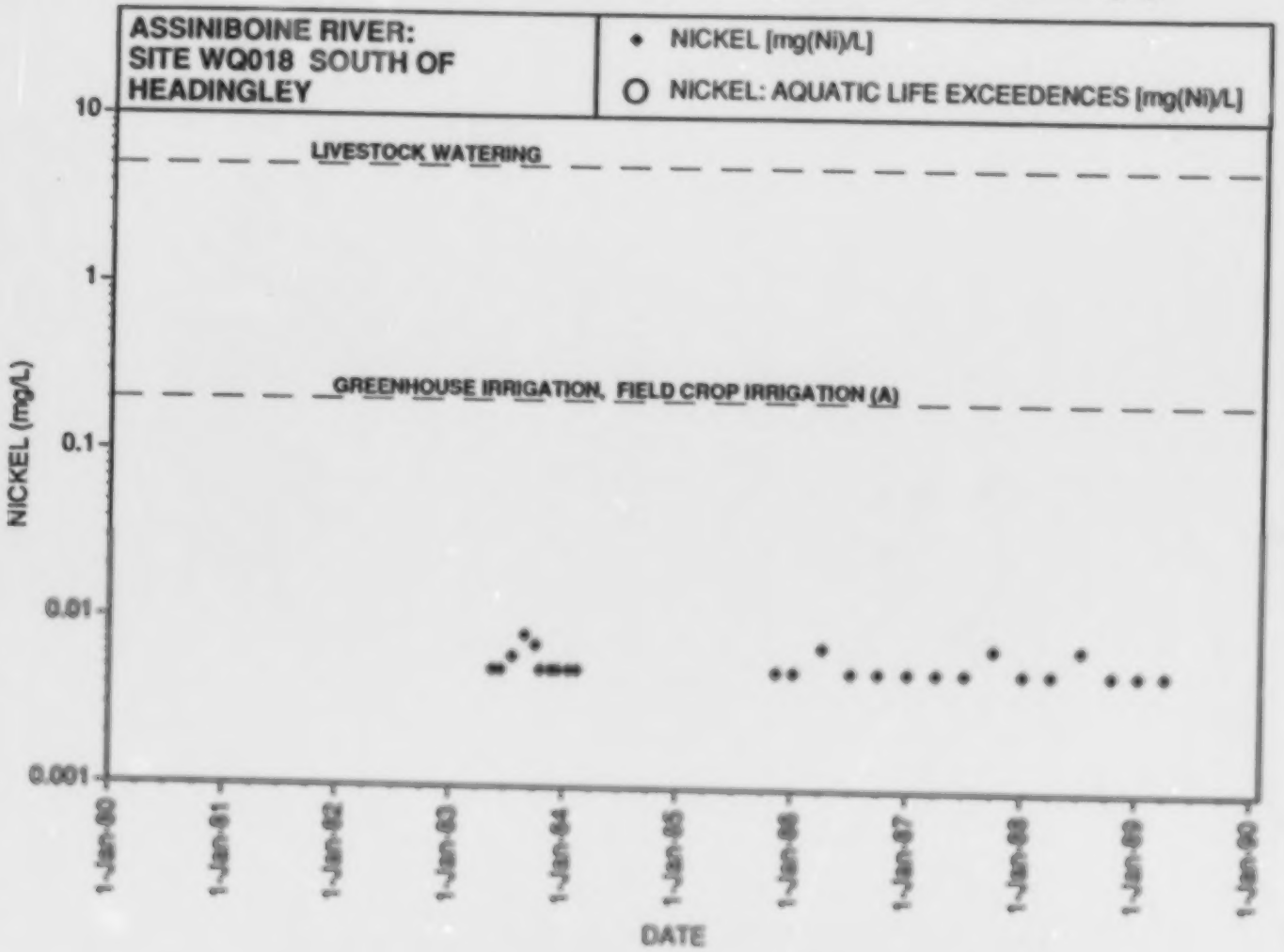


FIGURE 158: Nickle concentrations in the Red River at site WQ367 at the south gate of the Floodway.

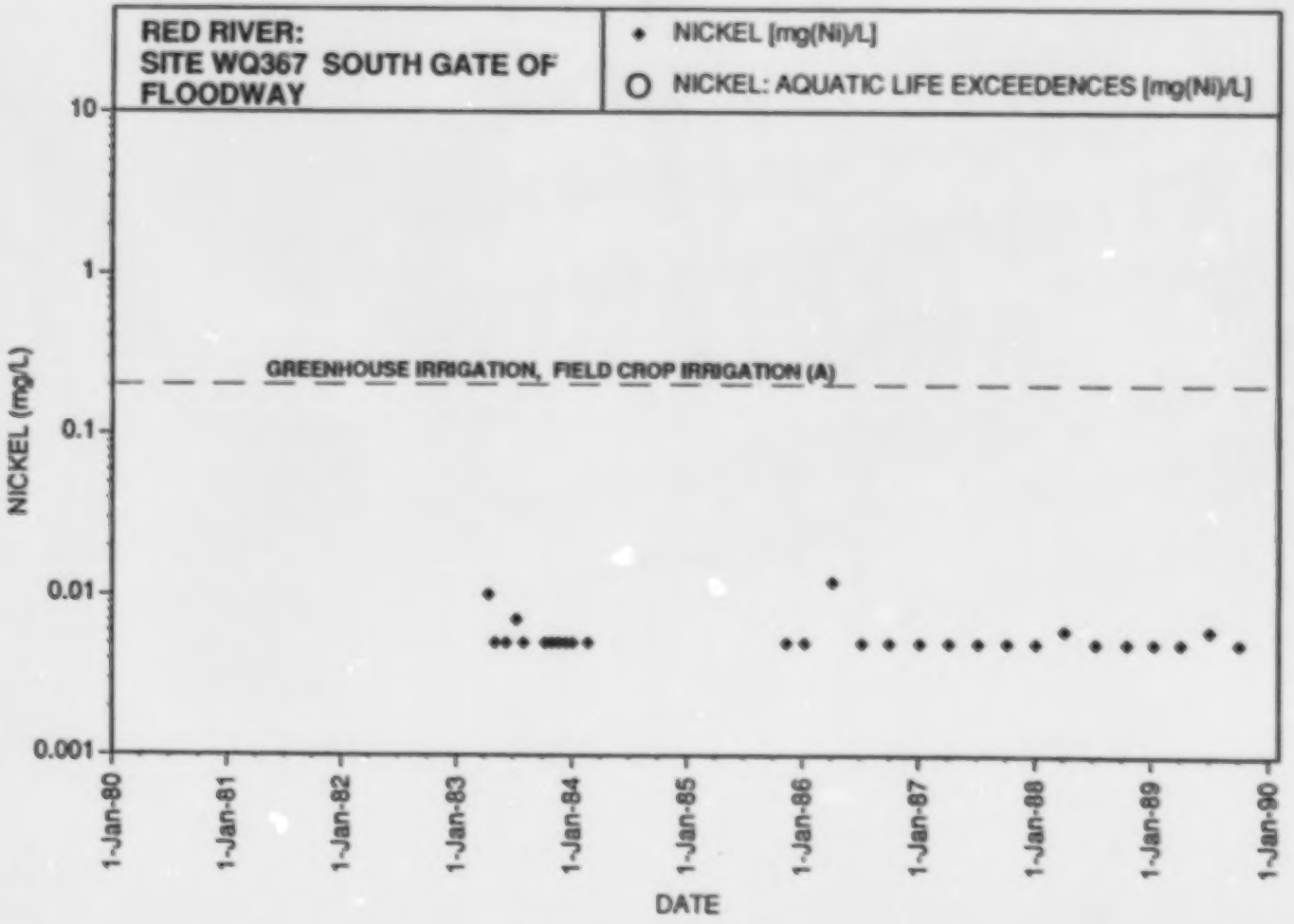


FIGURE 159: Nickle concentrations in the Red River at site WQ142 at Selkirk.

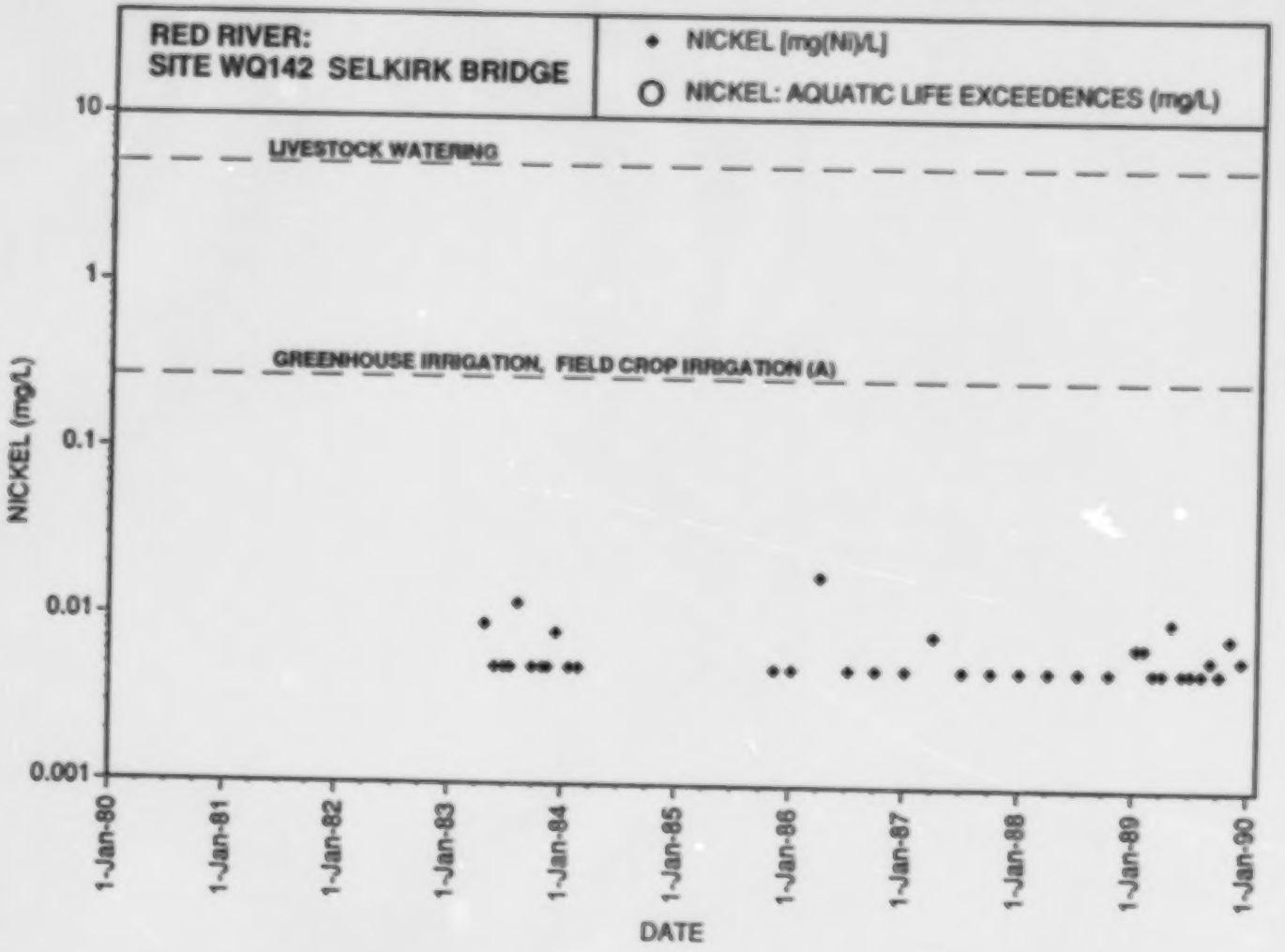


FIGURE A160: Zinc concentrations in the Assiniboine River, at site WQ018 at Headingley.

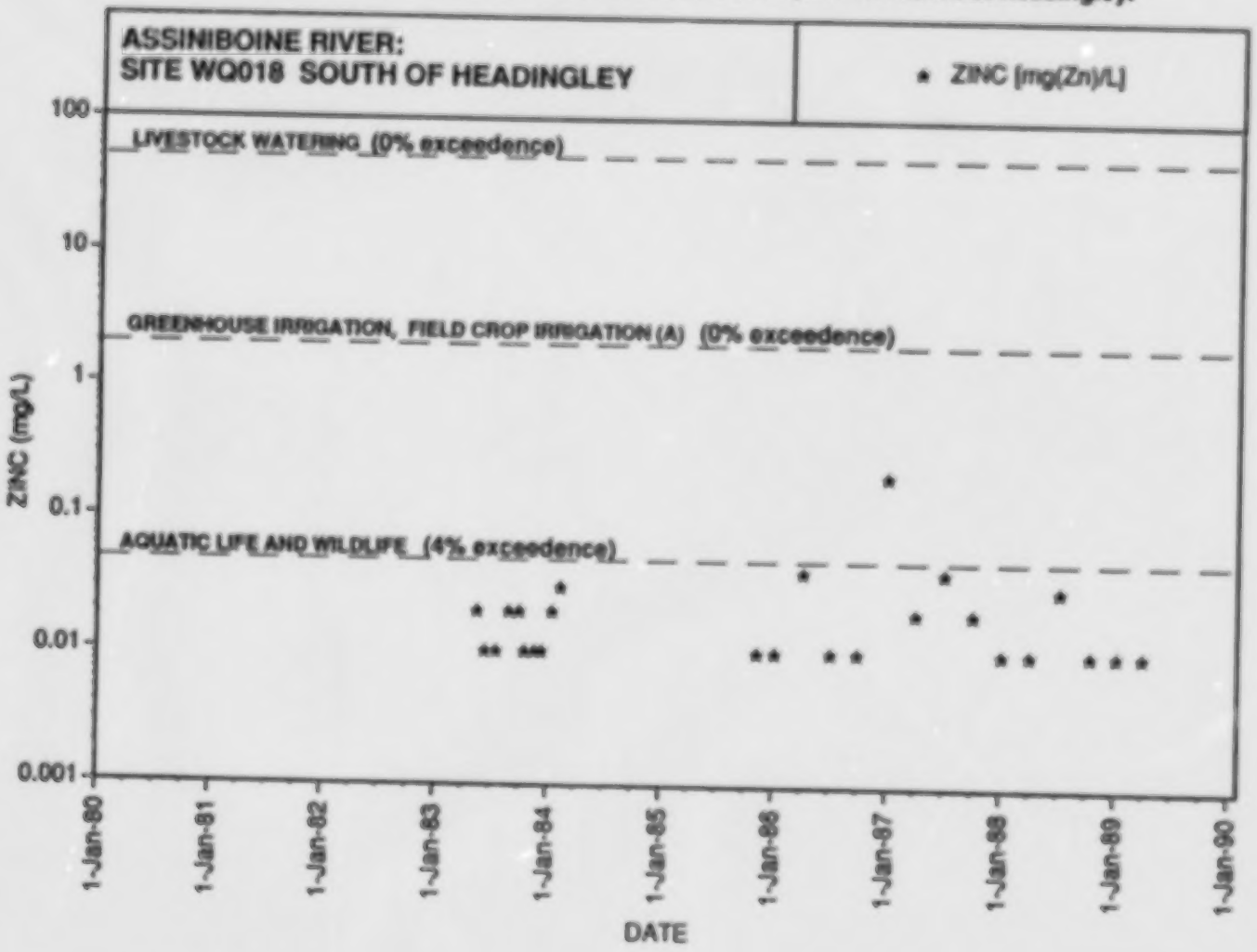


FIGURE A161: Zinc concentrations in the Red River, at site WQ367 at the south gate of the Floodway.

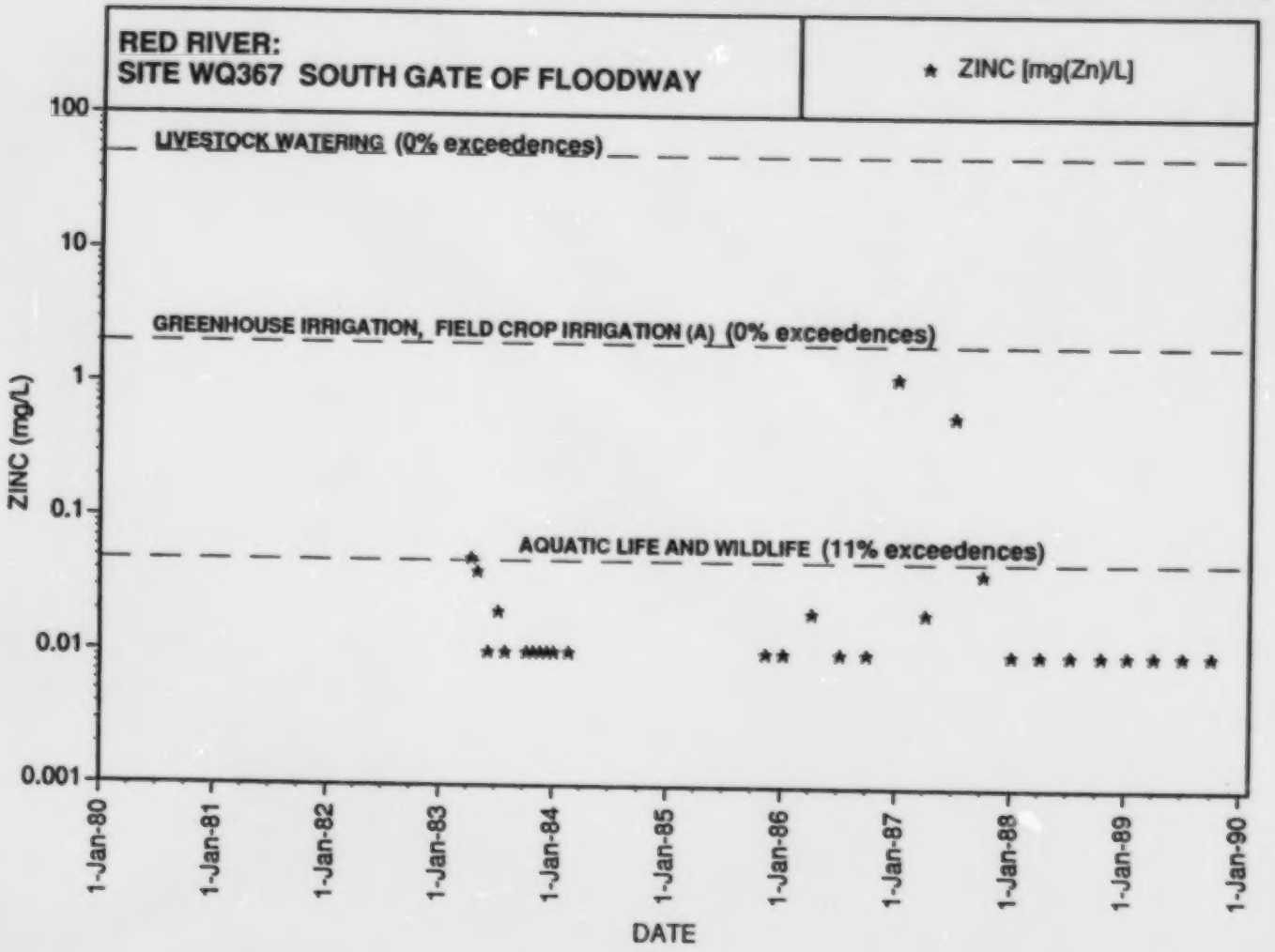


FIGURE A162: Zinc concentrations in the Red River, at site WQ142 at Selkirk.

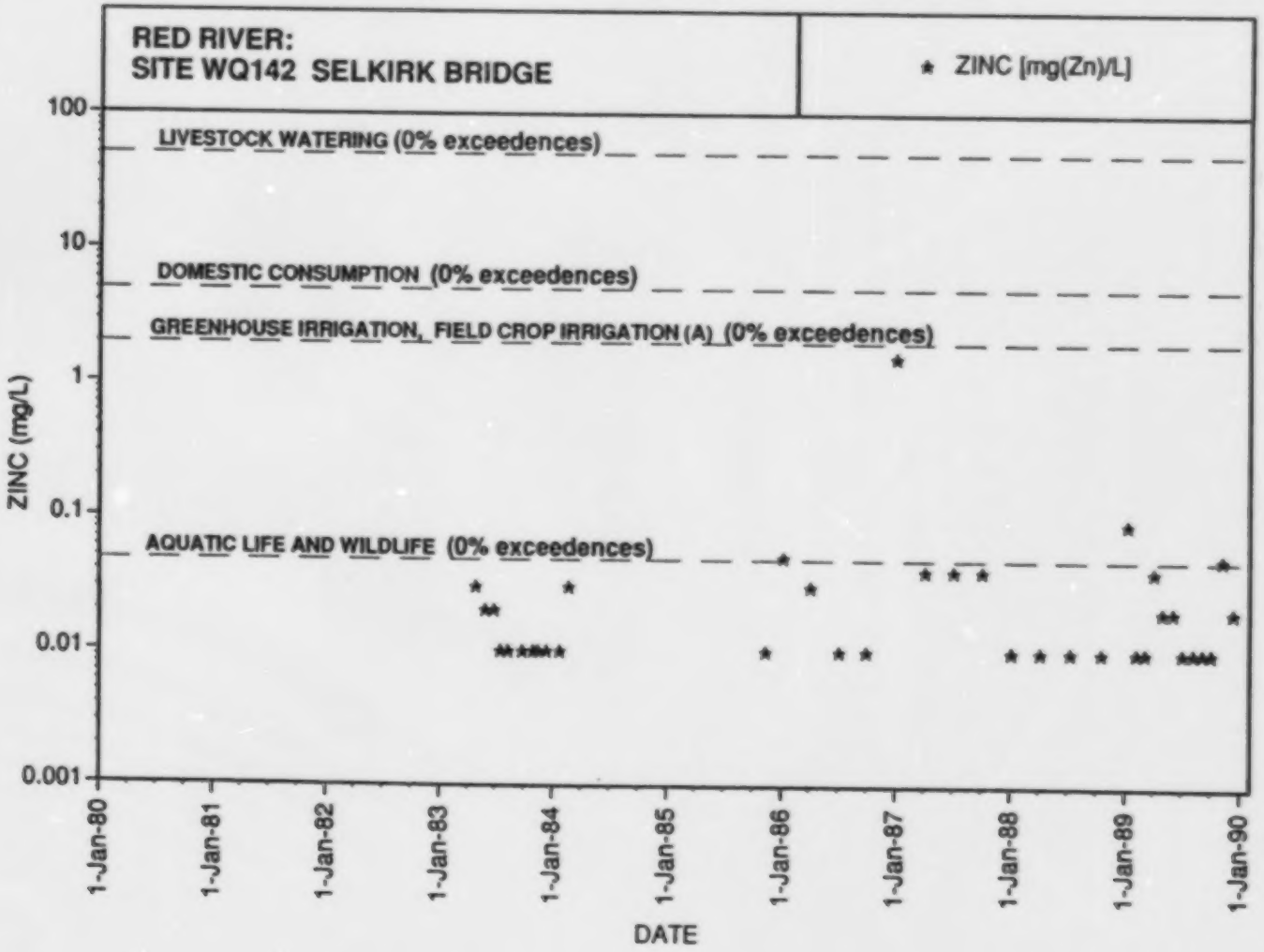


FIGURE A163: Organic carbon concentrations in the Assiniboine River, at site WQ018 at Headingley.

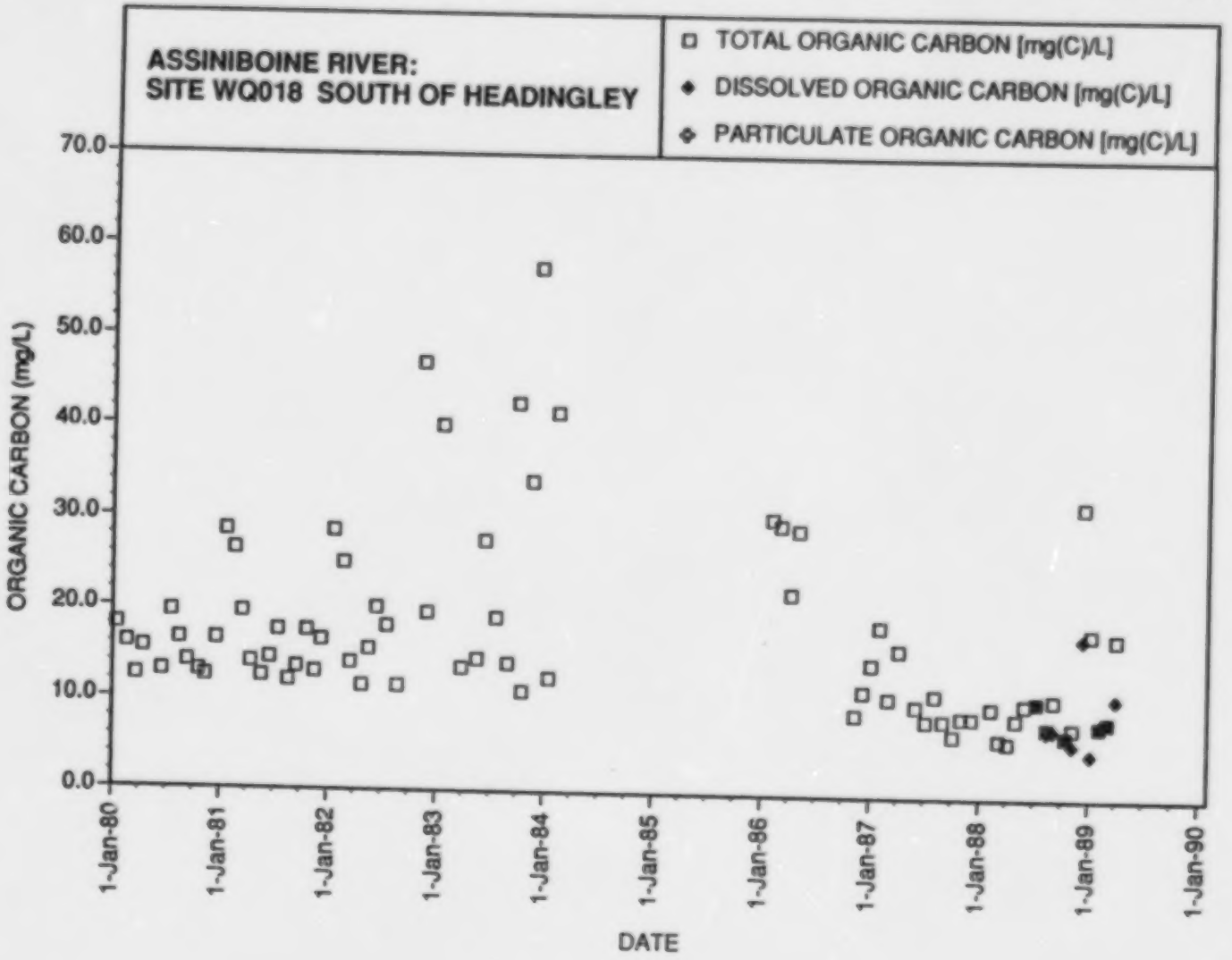


FIGURE A164: Organic carbon concentrations in the Assiniboine River at site WQ451 at Headingley.

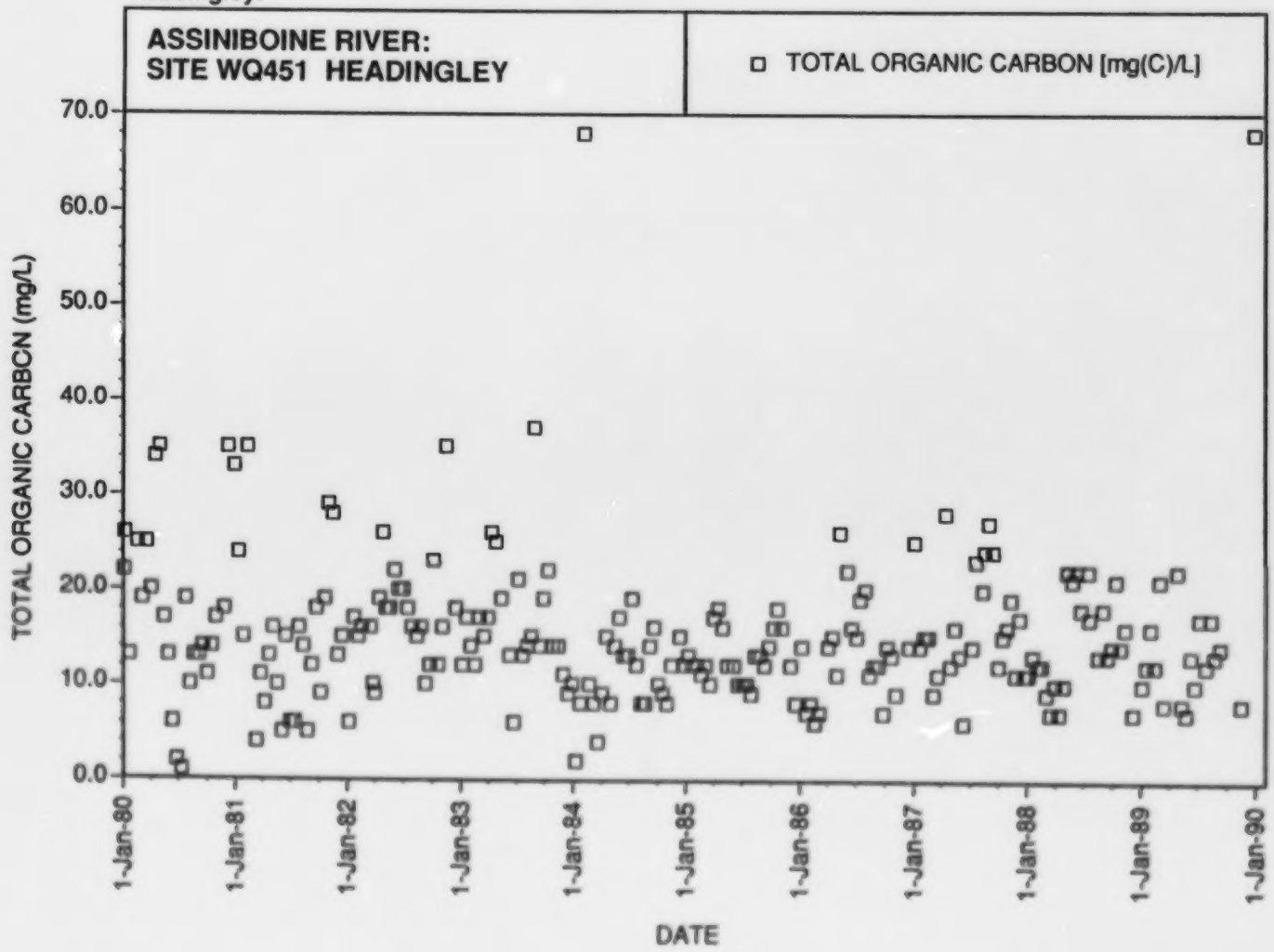


FIGURE A165: Organic carbon concentrations in the Assiniboine River at site WQ452 at the west perimeter.

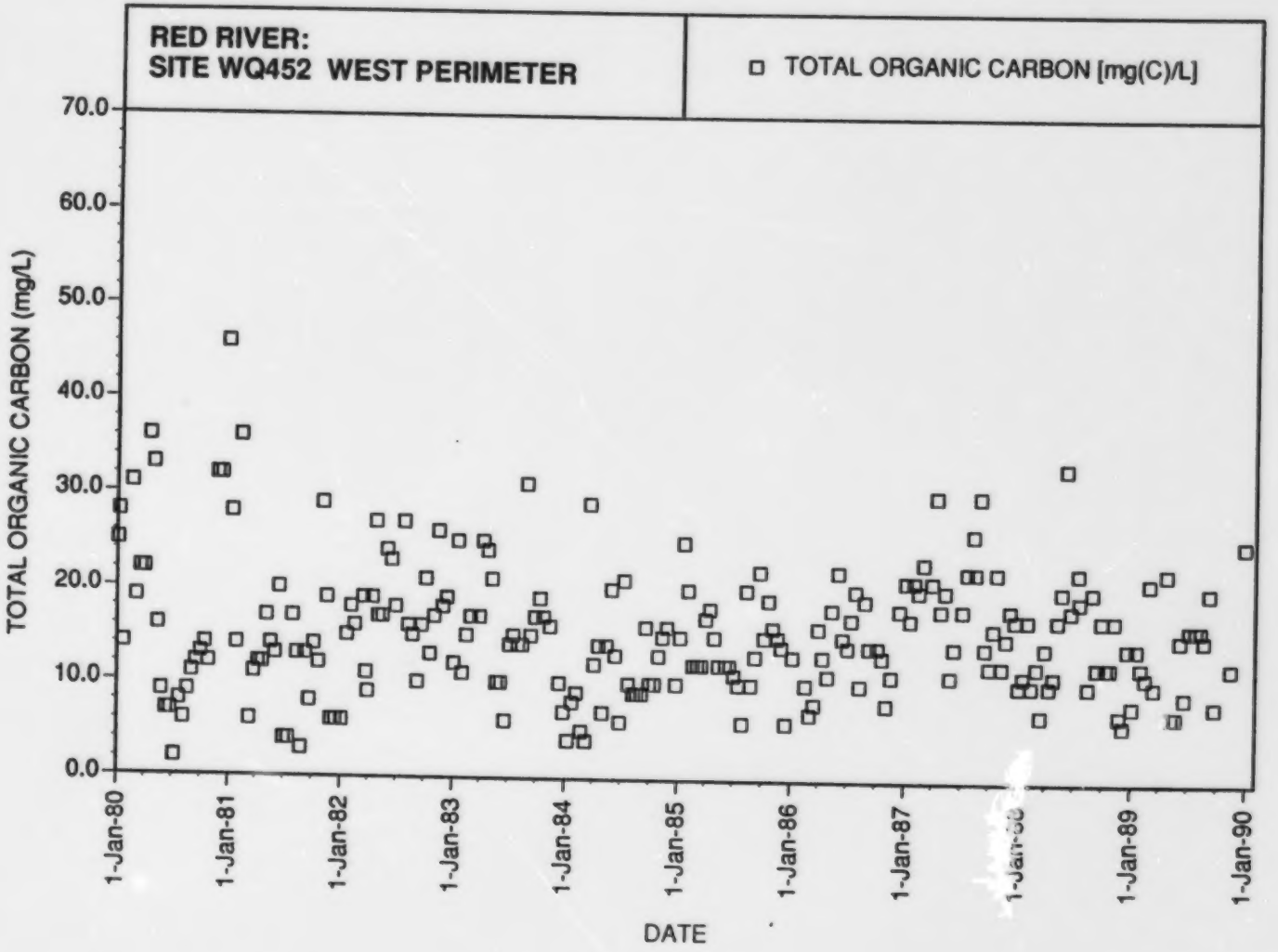


FIGURE A166: Organic carbon concentrations in the Assiniboine River at site WQ453 at the Main Street Bridge.

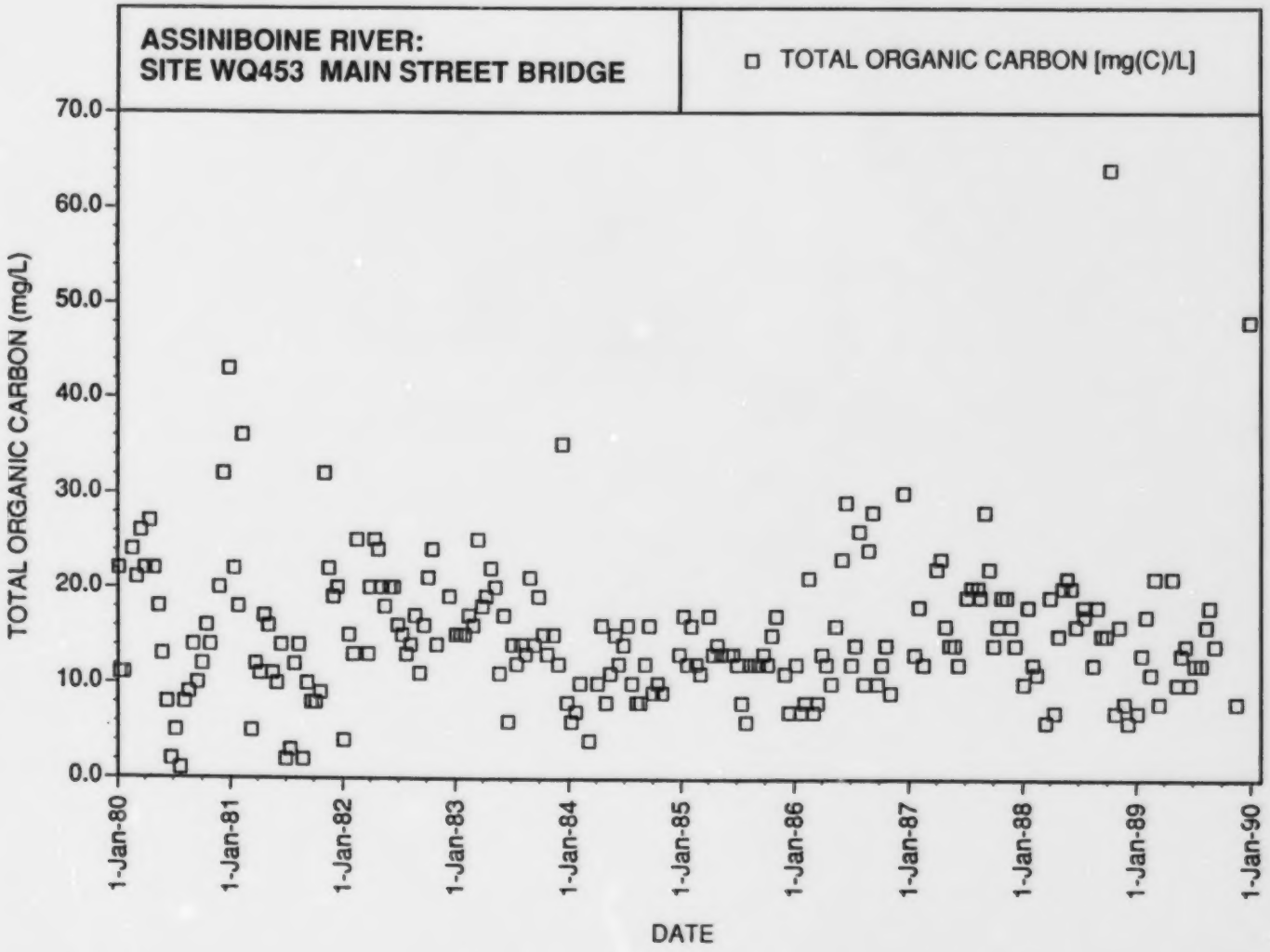


FIGURE A167: Organic carbon concentrations in the Red River at site WQ367 the south gate of the Floodway.

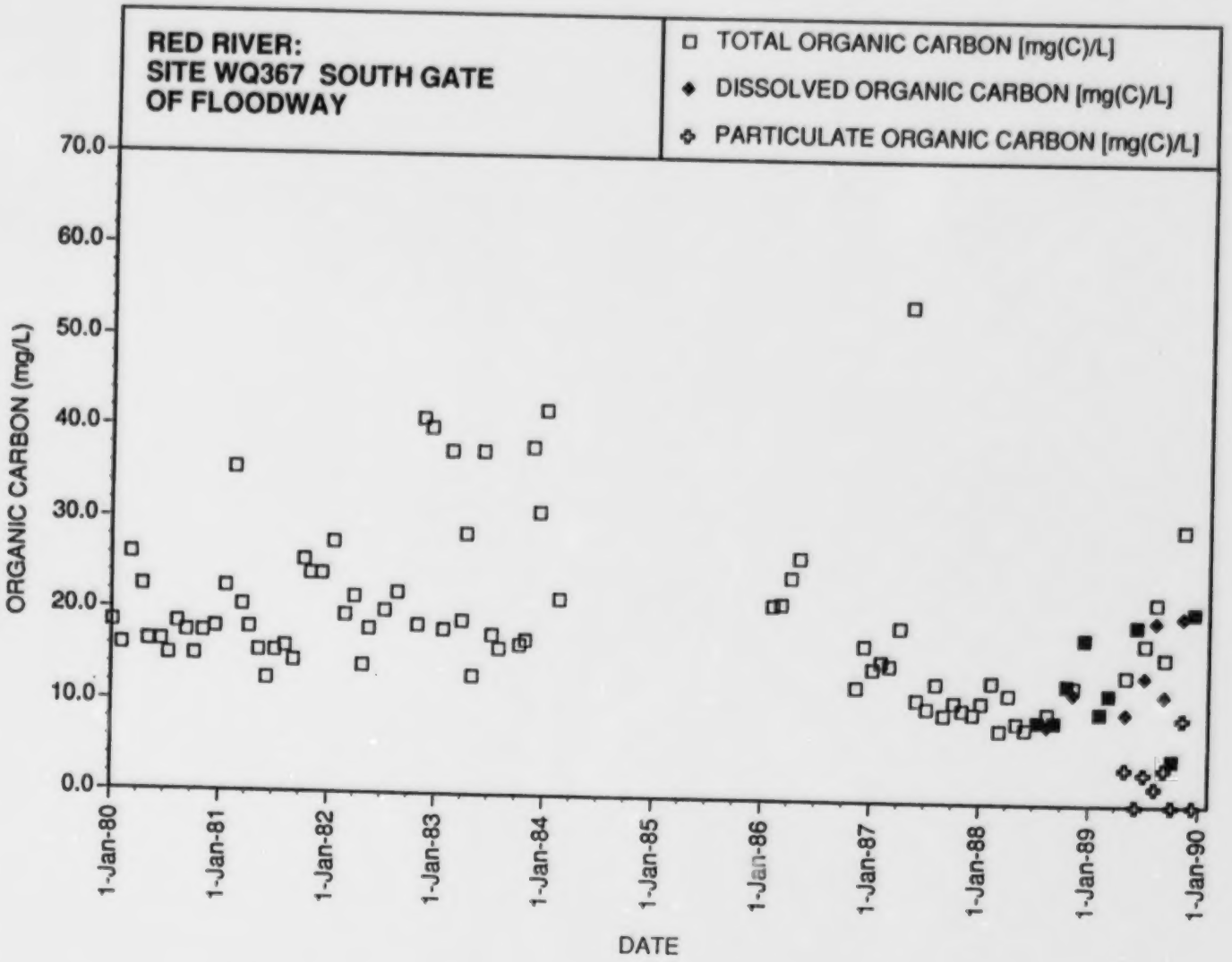


FIGURE A168: Organic carbon concentrations in the Red River at site WQ445 at the south Floodway control.

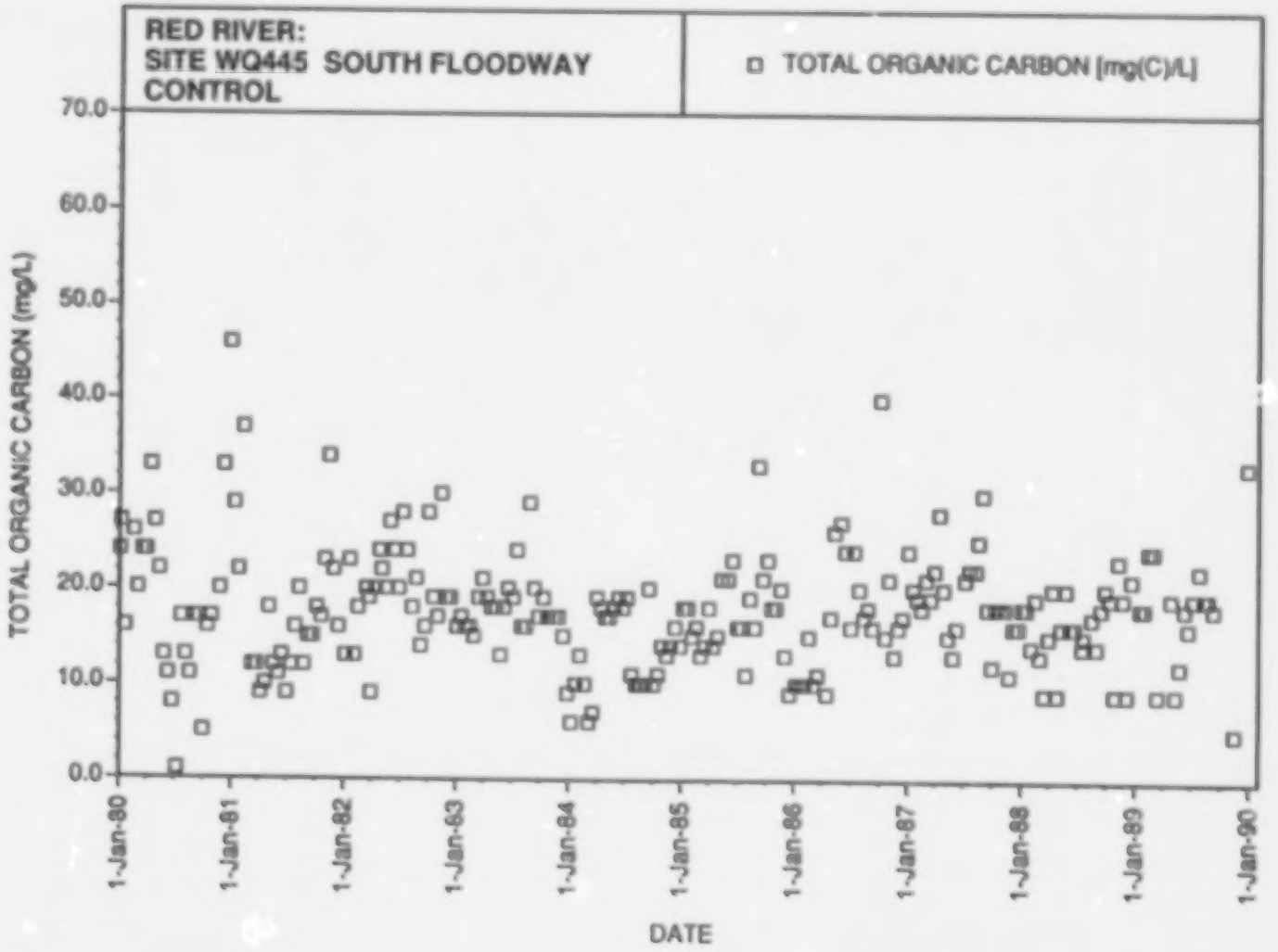


FIGURE A169: Organic carbon concentrations in the Red River at site WQ576 at the Fort Gary Bridge.

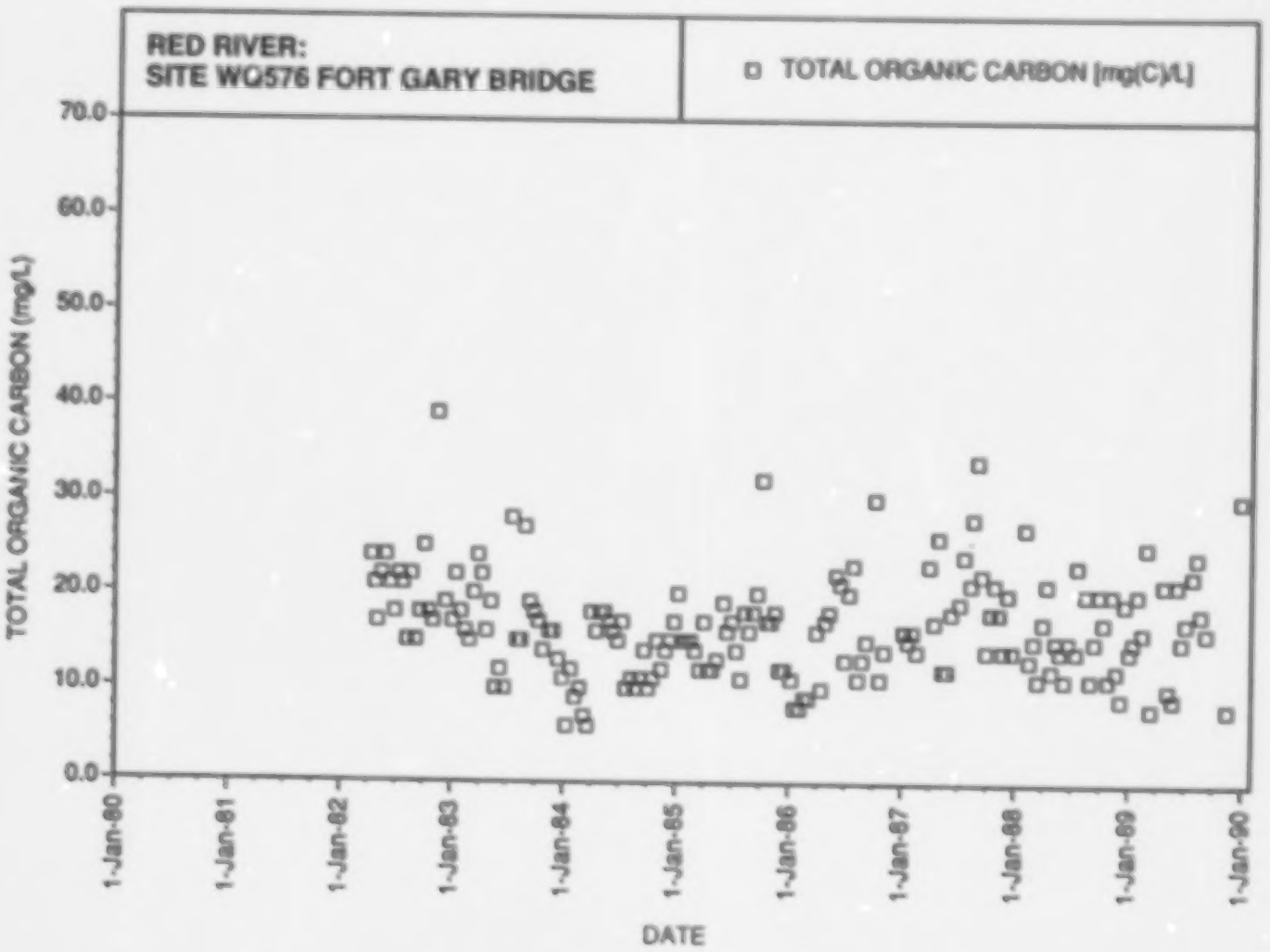


FIGURE A170: Organic carbon concentrations in the Red River at site WQ447 at the Norwood Bridge.

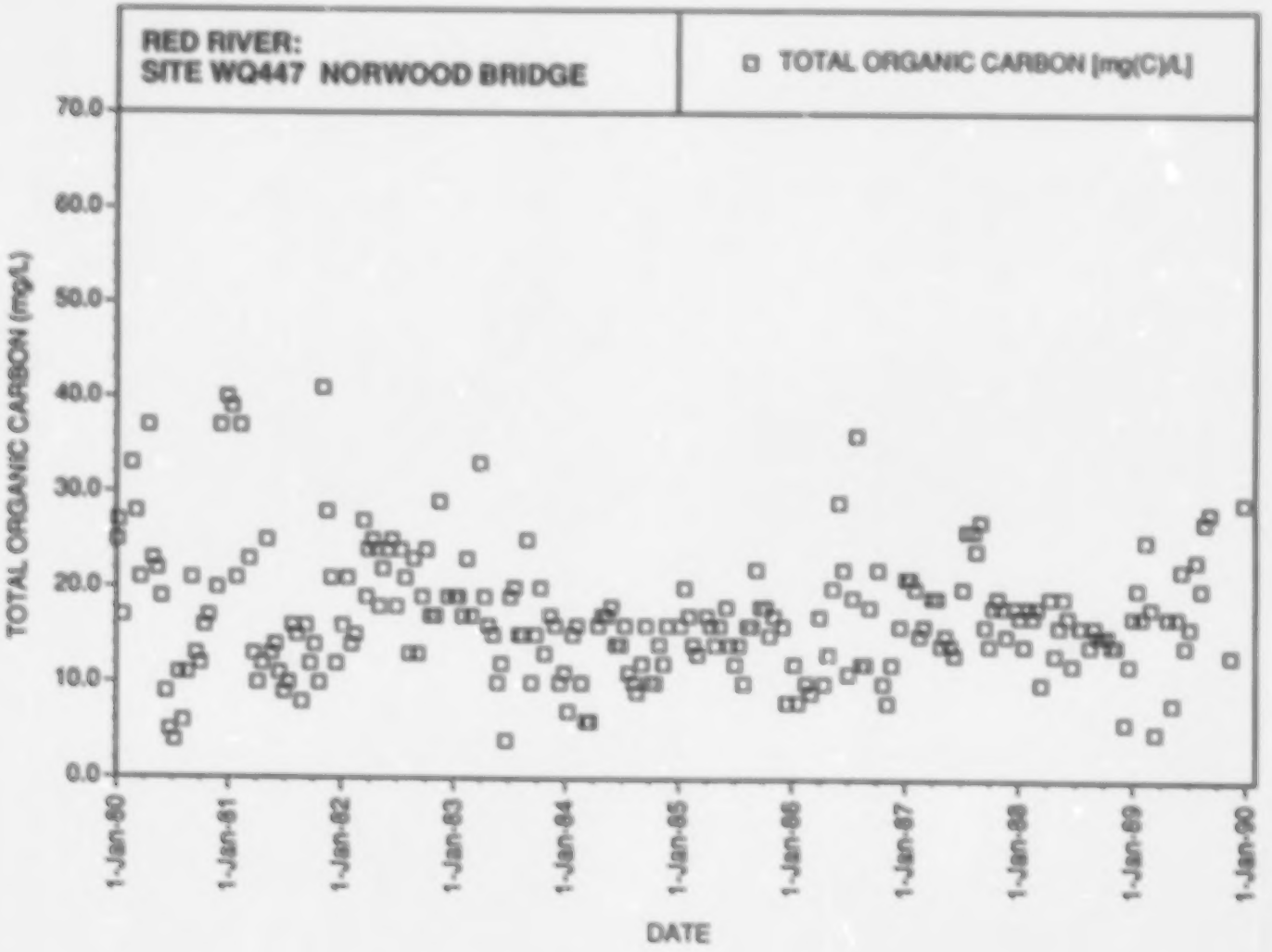


FIGURE A171: Organic carbon concentrations in the Red River at site WQ448 at the Redwood Bridge.

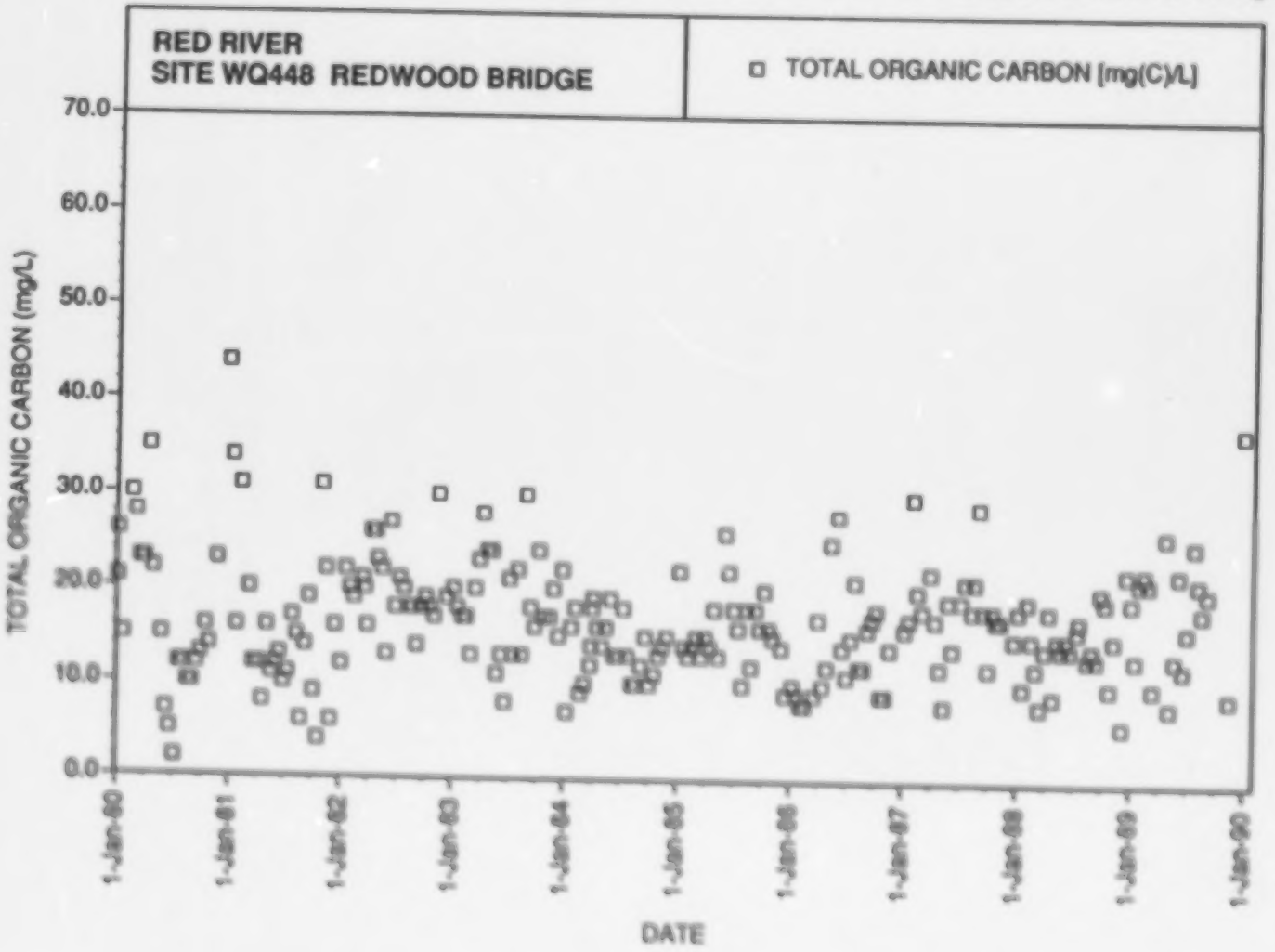


FIGURE A172: Organic carbon concentrations in the Red River at site WQ449 at the North perimeter.

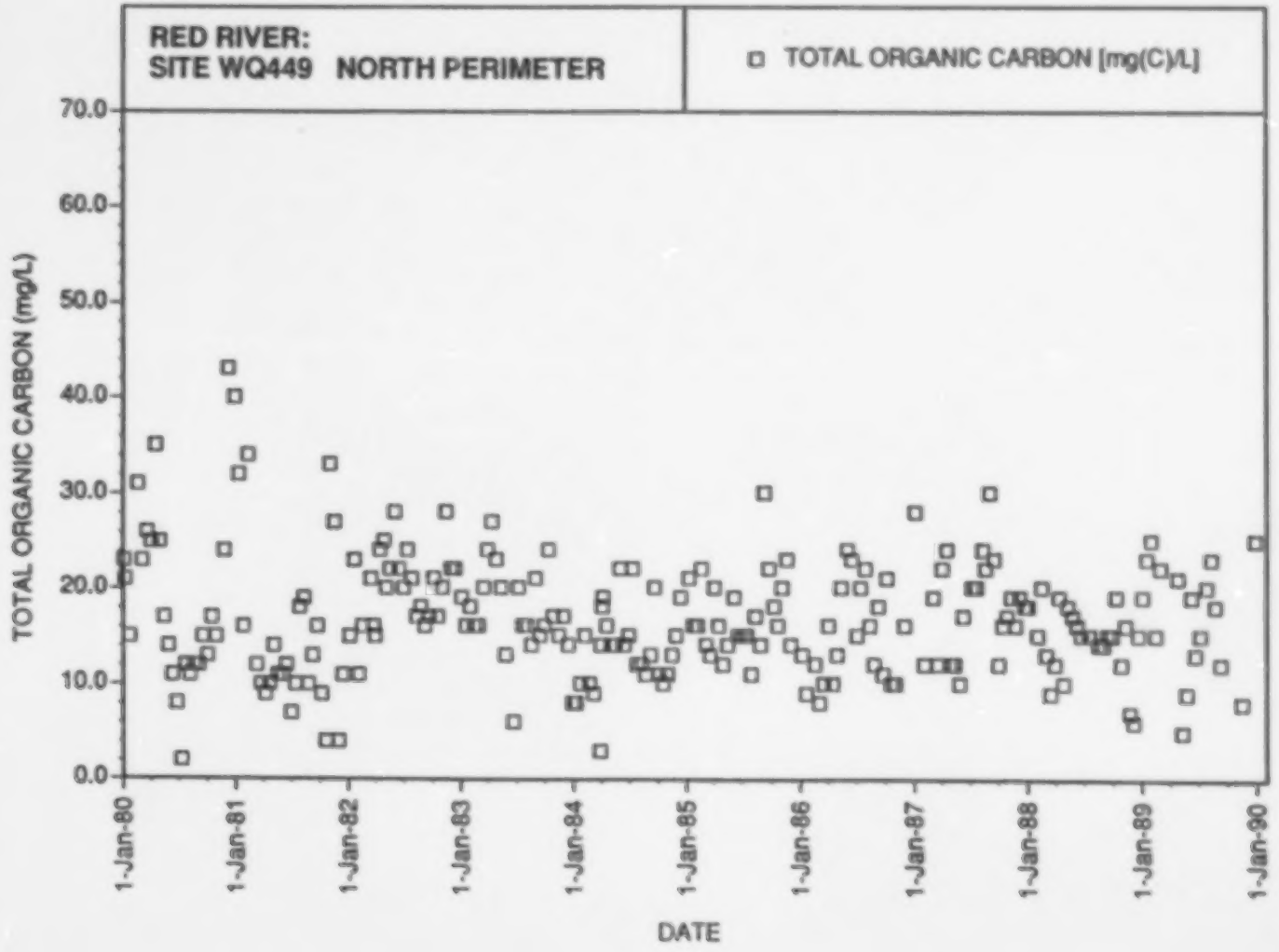


FIGURE A173: Organic carbon concentrations in the Red River at site WQ450 at Lockport.

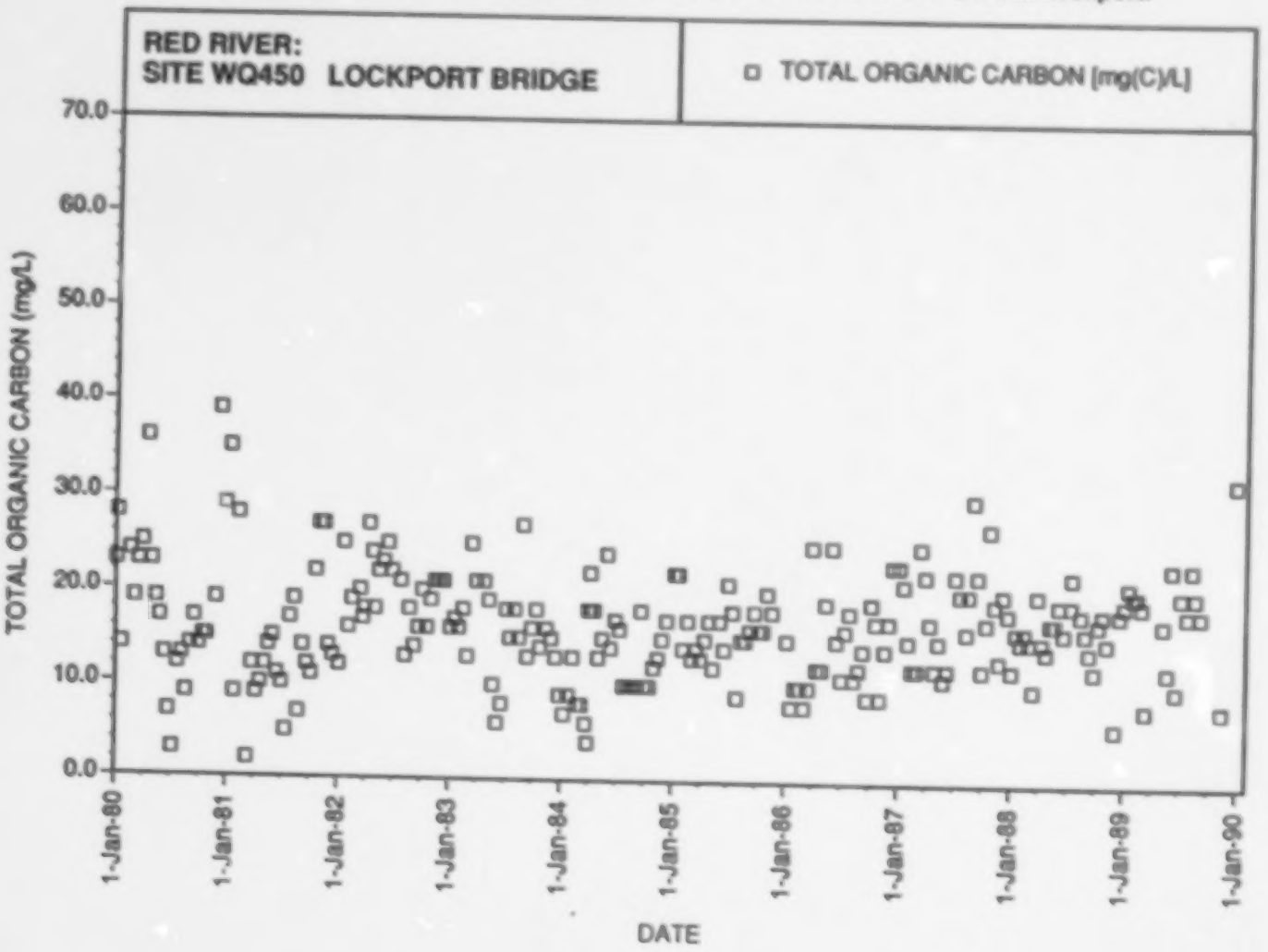


FIGURE A174: Organic carbon concentrations in the Red River at site WQ142 at Selkirkt.

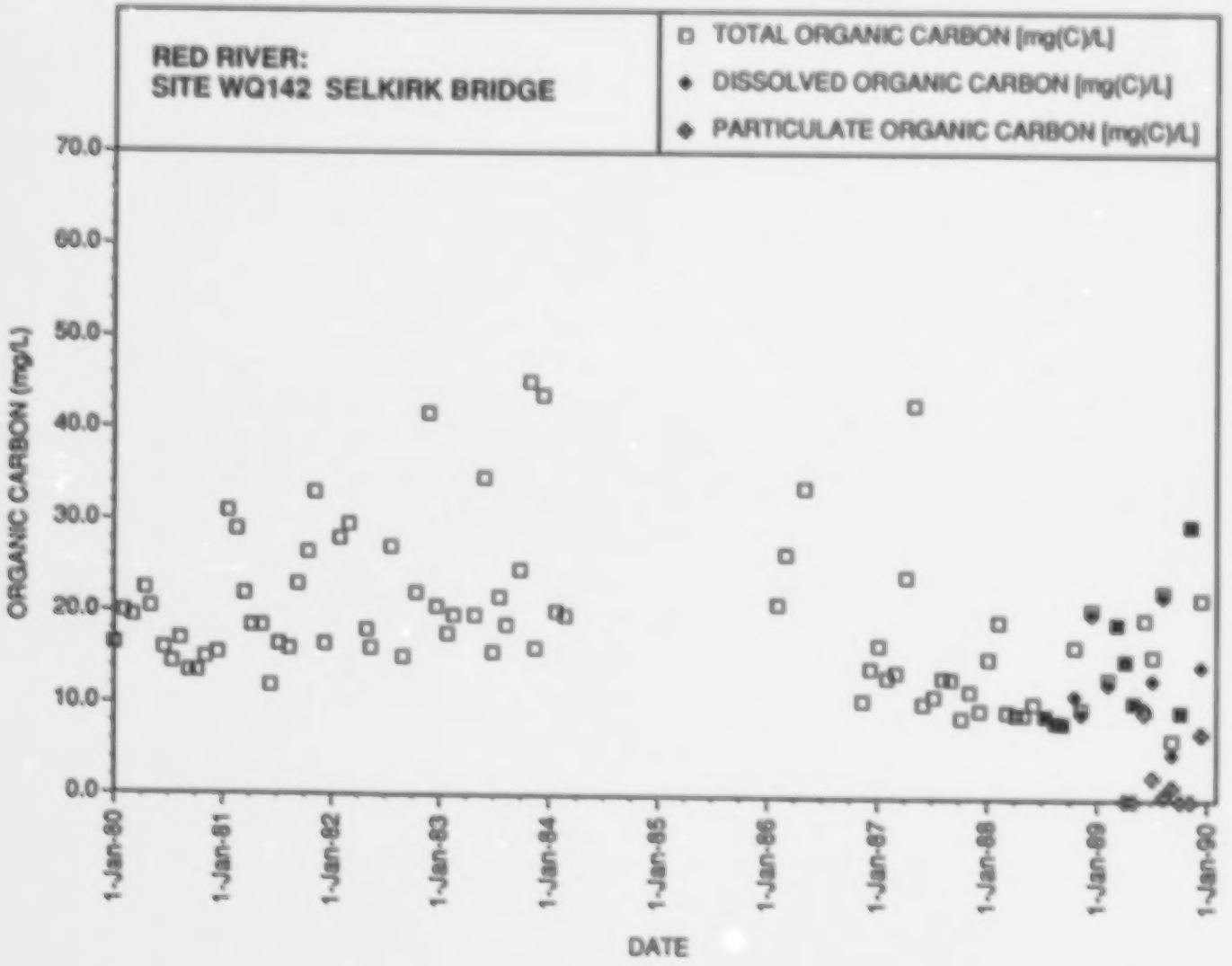


TABLE A93: Trend analysis and paired t-test results on total organic carbon data.

TREND ANALYSIS RESULTS: TOTAL ORGANIC CARBON. (ENTIRE PERIOD OF RECORD UTILIZED FOR THESE ANALYSES)				
SAMPLING LOCATION	R2	P VALUE	TREND	N
ASSINIBOINE RIVER SITES:				
WQ018 SOUTH OF HEADINGLEY	0.06	0.005 **	DECREASING	125
WQ451 HEADINGLEY	0.03	0.006 **	DECREASING	280
WQ452 WEST PERIMETER	0.04	0.001 **	DECREASING	285
WQ453 MAIN STREET BRIDGE	0.02	0.032 *	DECREASING	273
RED RIVER SITES:				
WQ367 SOUTH GATE OF FLOODWAY	0.09	0.002 **	DECREASING	110
WQ445 FLOODWAY CONTROL	0.01	0.094 N/S	DECREASING	289
WQ576 FORT GARY BRIDGE	0.00	0.597 N/S	DECREASING	179
WQ447 NORWOOD BRIDGE	0.03	0.007 **	DECREASING	275
WQ448 REDWOOD BRIDGE	0.02	0.009 **	DECREASING	281
WQ449 NORTH PERIMETER	0.03	0.006 **	DECREASING	282
WQ450 LOCKPORT BRIDGE	0.02	0.014 *	DECREASING	289
WQ142 SELKIRK	0.01	0.323 N/S	DECREASING	155

PAIRED T-TEST RESULTS: TOTAL ORGANIC CARBON DATA UPSTREAM vs DOWNSTREAM OF WINNIPEG. (1980-1989)				
COMPARISON	SITE WITH HIGHER MEAN VALUE	P VALUE	MEAN DIFFERENCE (mg/L)	DEGREES OF FREEDOM
SOUTH HEADINGLEY vs SELKIRK	SELKIRK	0.515 N/S	-6.40	61
SOUTH FLOODWAY vs SELKIRK	SELKIRK	0.684 N/S	-0.33	78
SOUTH HEADINGLEY vs SOUTH FLOODWAY	SOUTH FLOODWAY	0.326 N/S	-0.93	63

* indicates significance level of $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend/difference ($P>0.05$)
~ indicates insufficient data to perform analysis

TABLE A94: PESTICIDE CONCENTRATIONS IN WATER SAMPLES COLLECTED AT SITE WQ018 AT HEADINGLEY ON THE ASSINIBOINE RIVER.

DATE	TRIALLATE	TRIFLURALIN	BROMOXYNIL	DICLOFOP-METHYL	2, 4 - D
	µg/L	µg/L	µg/L	µg/L	µg/L
13-Nov-85	1.00 L	0.006 L	0.10 L	0.04 L	0.10 L
8-Jan-86	1.00 L	0.006 L	0.10 L	0.04 L	0.10 L
9-Apr-86	1.00 L	0.006 L	0.10 L	0.04 L	0.10 L
7-Jul-86	1.00 L	0.006 L	0.10 L	0.04 L	0.10 L
1-Oct-86	1.00 L	0.006 L	0.10 L	0.04 L	0.10 L
5-Jan-87	1.00 L	0.006 L	0.01 L	0.04 L	0.05 L
6-Apr-87	1.00 L	0.012	0.01 L	0.04 L	0.05 L
6-Jul-87	1.00 L	0.010 L	0.01 L	0.05 L	0.05 L
5-Oct-87	1.00 L	0.010 L	0.01 L	0.05 L	0.05 L
6-Jan-88	1.00 L	0.010 L	0.01 L	0.05 L	0.05 L
5-Apr-88	1.00 L	0.010 L	0.01 L	0.05 L	0.05 L
11-Jul-88	1.00 L	0.010 L	0.01 L	0.05 L	0.05 L
17-Oct-88	1.00 L	0.030 L	0.01 L	0.09 L	0.05 L
4-Apr-89	1.00 L	0.030 L	0.01 L	0.09 L	0.05 L

Continued.....

TABLE A94: CONTINUED.

DATE	LINDANE (BHC)	PICLORAM	PROPANIL	SIMAZINE
	µg/L	µg/L	µg/L	µg/L
13-Nov-85	0.001 L	---	---	---
8-Jan-86	---	0.10 L	1.0 L	---
9-Apr-86	0.001 L	0.10 L	1.0 L	---
7-Jul-86	0.001 L	0.10 L	1.0 L	---
1-Oct-86	0.001 L	0.10 L	1.0 L	---
5-Jan-87	0.001 L	0.10 L	1.0 L	---
6-Apr-87	0.003	0.20 L	1.0 L	---
6-Jul-87	0.010 L	0.20 L	1.0 L	---
5-Oct-87	0.010 L	0.20	1.0 L	---
6-Jan-88	0.010 L	0.20 L	0.0 L	---
5-Apr-88	0.010 L	0.20 L	1.0 L	---
11-Jul-88	0.010 L	0.20 L	1.0 L	0.50 L
17-Oct-88	0.020 L	0.40 L	1.0 L	0.50 L
4-Apr-89	0.020 L	0.20 L	1.0 L	---

Values are qualified by "L" when analytical procedures were not capable of greater accuracy. Data should thus be interpreted accordingly.

TABLE A95: PESTICIDE CONCENTRATIONS IN WATER SAMPLES COLLECTED AT SITE WQ367 AT SOUTH FLOODWAY ON THE RED RIVER.

DATE	TRIALLATE	TRIFLURALIN	DICAMBA	BROMOXYNIL	DICLOF-METH	2, 4 - D
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
14-Nov-85	1.00 L	0.006 L	---	0.10 L	0.04 L	0.10 L
9-Jan-86	1.00 L	0.006 L	---	0.10 L	0.04 L	0.10 L
8-Apr-86	1.00 L	0.006 L	---	0.10 L	0.04 L	0.10 L
8-Jul-86	1.00 L	0.006 L	---	0.10 L	0.04 L	0.10 L
2-Oct-86	1.00 L	0.006 L	---	0.10 L	0.04 L	0.13
6-Jan-87	1.00 L	0.006 L	---	0.01 L	0.04 L	0.05 L
7-Apr-87	1.00 L	0.030	---	0.01 L	0.04 L	0.05 L
7-Jul-87	1.00 L	0.010 L	---	0.01 L	0.05 L	0.05 L
6-Oct-87	1.00 L	0.010 L	---	0.01 L	0.05 L	0.05 L
6-Jan-88	1.00 L	0.010 L	---	0.01 L	0.05 L	0.05 L
6-Apr-88	1.00 L	0.020	---	0.01 L	0.05 L	0.05 L
12-Jul-88	1.00 L	0.010 L	---	0.01 L	0.05 L	0.13
18-Oct-88	1.00 L	0.030 L	---	0.01 L	0.09 L	0.05 L
5-Apr-89	1.00 L	0.030 L	---	0.01 L	0.09 L	0.05 L
5-Jul-89	1.00 L	0.030 L	0.02	0.01	1.20	0.10
4-Oct-89	1.00 L	0.030 L	---	0.01 L	0.09 L	0.05 L

CONTINUED.....

TABLE A95 : CONTINUED .

DATE	LINDANE (BHC)	PICLORAM	PROPANIL	SIMAZINE	ATRAZINE
	µg/L	µg/L	µg/L	µg/L	µg/L
14-Nov-85	0.001 L	---	---	---	---
9-Jan-86	---	0.10 L	1.0 L	---	---
8-Apr-86	0.001 L	0.10 L	1.0 L	---	---
8-Jul-86	0.005	0.10 L	1.0 L	---	---
2-Oct-86	0.001 L	0.10 L	1.0 L	---	---
6-Jan-87	0.001 L	0.10 L	1.0 L	---	---
7-Apr-87	0.002	0.20 L	1.0 L	---	---
7-Jul-87	0.010 L	0.20 L	1.0 L	---	---
6-Oct-87	0.010 L	0.20	1.0 L	---	0.50 L
6-Jan-88	0.010 L	0.20 L	0.0 L	---	---
6-Apr-88	0.010 L	0.20 L	1.0 L	---	0.50 L
12-Jul-88	0.010 L	0.20 L	1.0 L	0.50 L	0.50 L
18-Oct-88	0.020 L	0.40 L	1.0 L	0.50 L	0.50 L
5-Apr-89	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
5-Jul-89	0.020 L	0.20 L	1.0 L	---	0.50 L
4-Oct-89	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L

Values are qualified by "L" when analytical procedures were not capable of greater accuracy. Data should thus be interpreted accordingly.

TABLE A96: PESTICIDE CONCENTRATIONS IN WATER SAMPLES COLLECTED AT SITE WQ142 AT SELKIRK ON THE RED RIVER.

DATE	TRIALLATE	TRIFLURALIN	DICAMBA	M C P A	BROMOXYNIL	DICLOFOP-METHYL
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
14-Nov-85	1.00 L	0.006 L	---	---	0.10 L	0.04 L
9-Jan-86	1.00 L	0.006 L	---	---	0.10 L	0.04 L
8-Apr-86	1.00 L	0.006 L	---	---	0.10 L	0.04 L
8-Jul-86	1.00 L	0.006 L	---	---	0.10 L	0.04 L
2-Oct-86	1.00 L	0.006 L	---	---	0.10 L	0.04 L
6-Jan-87	1.00 L	0.006 L	---	---	0.01 L	0.04 L
7-Apr-87	1.00 L	0.045	---	---	0.01	0.04 L
7-Jul-87	1.00 L	0.010 L	---	---	0.03	0.05 L
6-Oct-87	1.00 L	0.010 L	---	---	0.01 L	0.05 L
6-Jan-88	1.00 L	0.010 L	---	---	0.01 L	0.05 L
6-Apr-88	1.00 L	0.020	---	---	0.01	0.05 L
12-Jul-88	1.00 L	0.010 L	0.03	---	0.01	0.05 L
18-Oct-88	1.00 L	0.030 L	---	---	0.02	0.09 L
7-Feb-89	1.00 L	0.160	---	---	0.01 L	0.09 L
8-Mar-89	1.00 L	0.090	1.30	28	0.01	0.09 L
5-Apr-89	1.00 L	0.030 L	---	---	0.02	0.09 L
3-May-89	1.00 L	0.030 L	---	---	0.01 L	0.09 L
7-Jun-89	1.00 L	0.030 L	---	---	0.01 L	0.09 L
5-Jul-89	1.00 L	0.030 L	---	---	0.01	0.09 L
9-Aug-89	1.00 L	0.030 L	0.03	---	0.08	0.09 L
7-Sep-89	1.00 L	0.030 L	0.02	---	0.01 L	0.09 L
4-Oct-89	1.00 L	0.030 L	0.60	---	0.08	0.09 L
8-Nov-89	1.00 L	0.030 L	0.64	---	0.01	0.09 L
13-Dec-89	1.00 L	0.030 L	---	---	0.01 L	0.05 L

CONTINUED.....

TABLE A96 : CONTINUED.

DATE	2, 4 - D	LINDANE (BHC)	PICLORAM	PROPANIL	SIMAZINE	ATRAZINE
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
14-Nov-85	0.10 L	0.001 L	---	---	---	---
9-Jan-86	0.10 L	---	0.10 L	1.0 L	---	---
8-Apr-86	0.10 L	0.001 L	0.10 L	1.0 L	---	---
8-Jul-86	0.10 L	0.001 L	0.10 L	1.0 L	---	---
2-Oct-86	0.10 L	0.008	0.10 L	1.0 L	---	---
6-Jan-87	0.05 L	0.001 L	0.10 L	1.0 L	---	---
7-Apr-87	0.29	0.002	0.20 L	1.0 L	---	---
7-Jul-87	0.17	0.010 L	0.20 L	1.0 L	---	---
6-Oct-87	0.07	0.010 L	0.20	1.0 L	---	0.50 L
6-Jan-88	0.05 L	0.010 L	0.20 L	0.0 L	---	---
6-Apr-88	0.08	0.010 L	0.20 L	1.0 L	---	0.50 L
12-Jul-88	0.22	0.010 L	0.20 L	1.0 L	0.50 L	0.50 L
18-Oct-88	0.22	0.020 L	0.40 L	1.0 L	0.50 L	0.50 L
7-Feb-89	1.30	0.010	---	1.0 L	---	---
8-Mar-89	3.40	0.020 L	---	1.0 L	---	---
5-Apr-89	0.14	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
3-May-89	0.05 L	0.020 L	0.20 L	1.0 L	---	---
7-Jun-89	0.05 L	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
5-Jul-89	0.07	0.020 L	0.20 L	1.0 L	---	0.50 L
9-Aug-89	0.06	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
7-Sep-89	0.05 L	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
4-Oct-89	0.27	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
8-Nov-89	0.29	0.020 L	0.20 L	1.0 L	0.50 L	0.50 L
13-Dec-89	0.05	0.020 L	0.20 L	1.0 L	0.50 L	---

Values are qualified by "L" when analytical procedures were not capable of greater accuracy. Data should thus be interpreted accordingly.

FIGURE A175: Fecal coliform concentrations in the Seine River at site T1 at Highway #59.

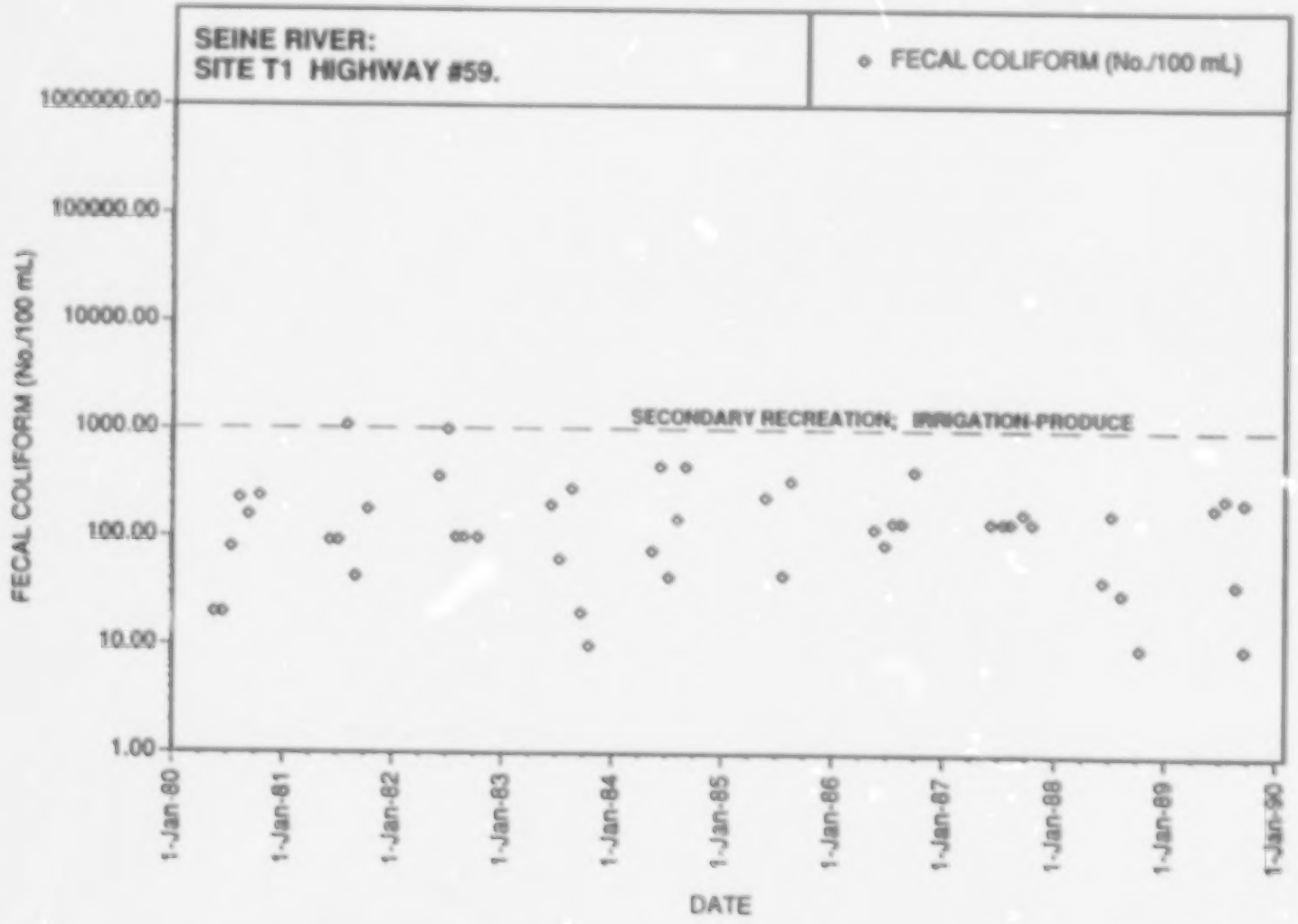


FIGURE A176: Fecal coliform concentrations in the Seine River, at site T2 at the Provencher Street Bridge.

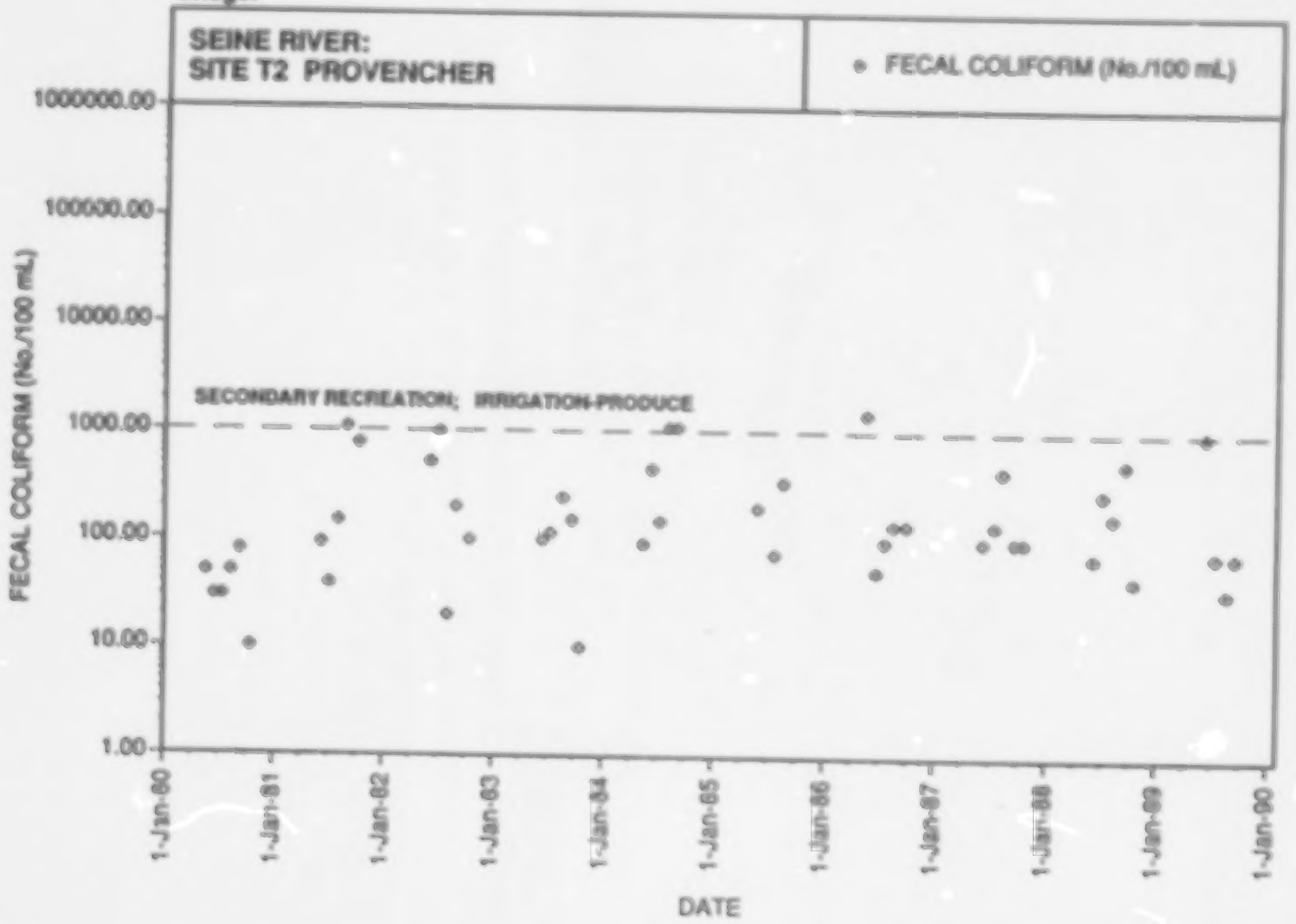


FIGURE A177: Fecal coliform concentrations in Sturgeon Creek, at site T3 at the perimeter.

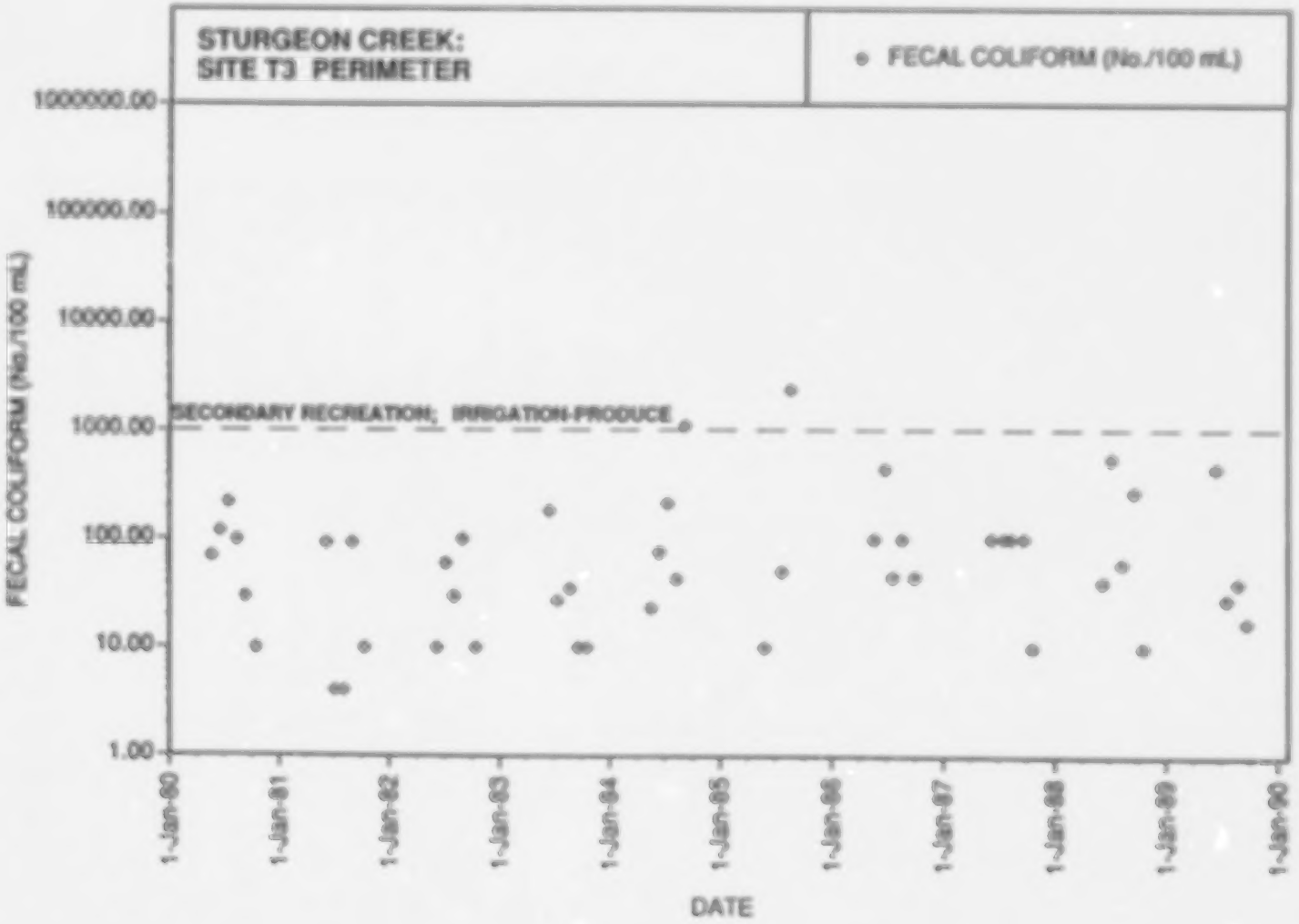


FIGURE A178: Fecal coliform concentrations in Sturgeon Creek, at site T4 at Portage Avenue.

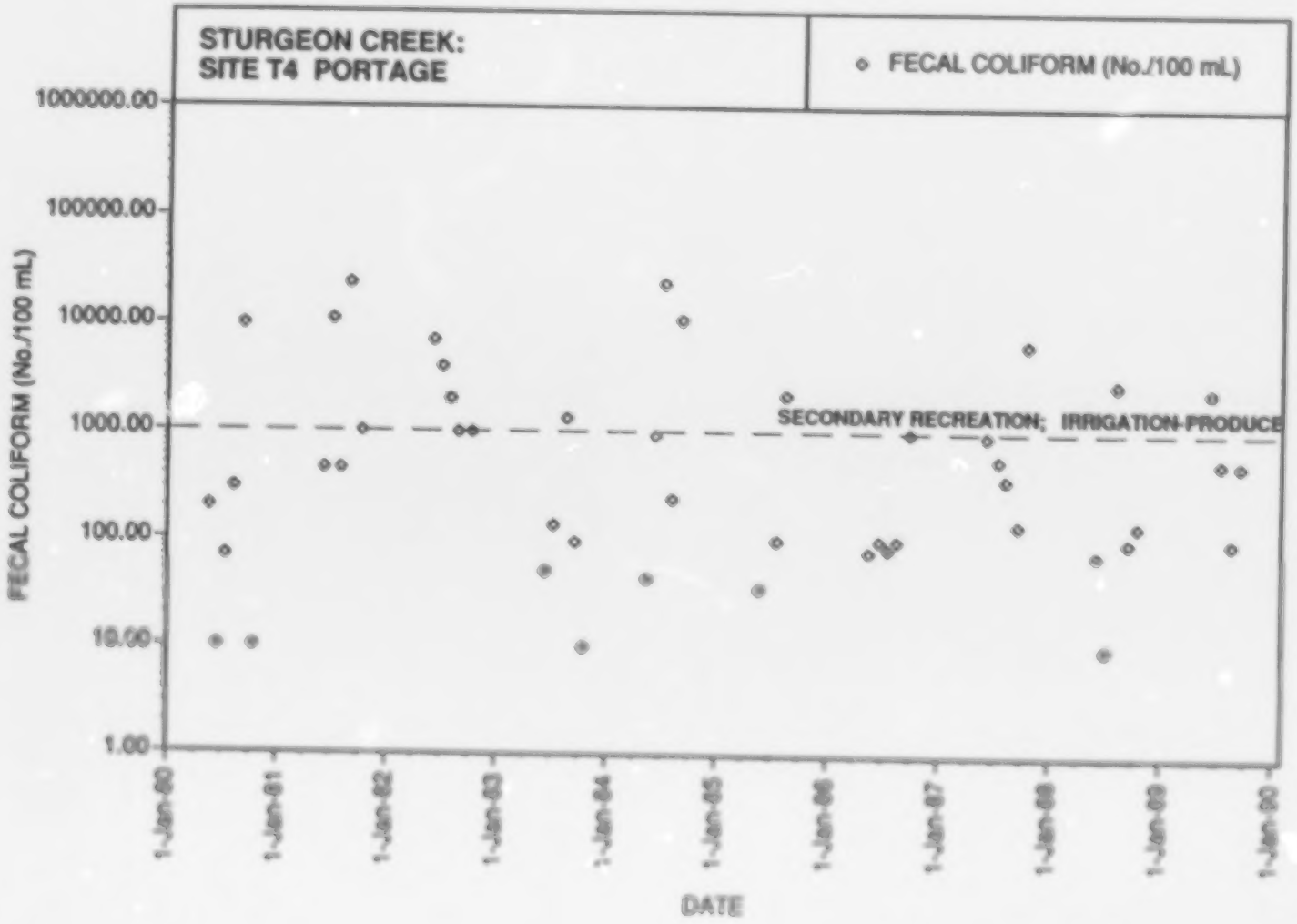


FIGURE A179: Fecal coliform concentrations in Omand's Creek, at site T5 at Portage Avenue.

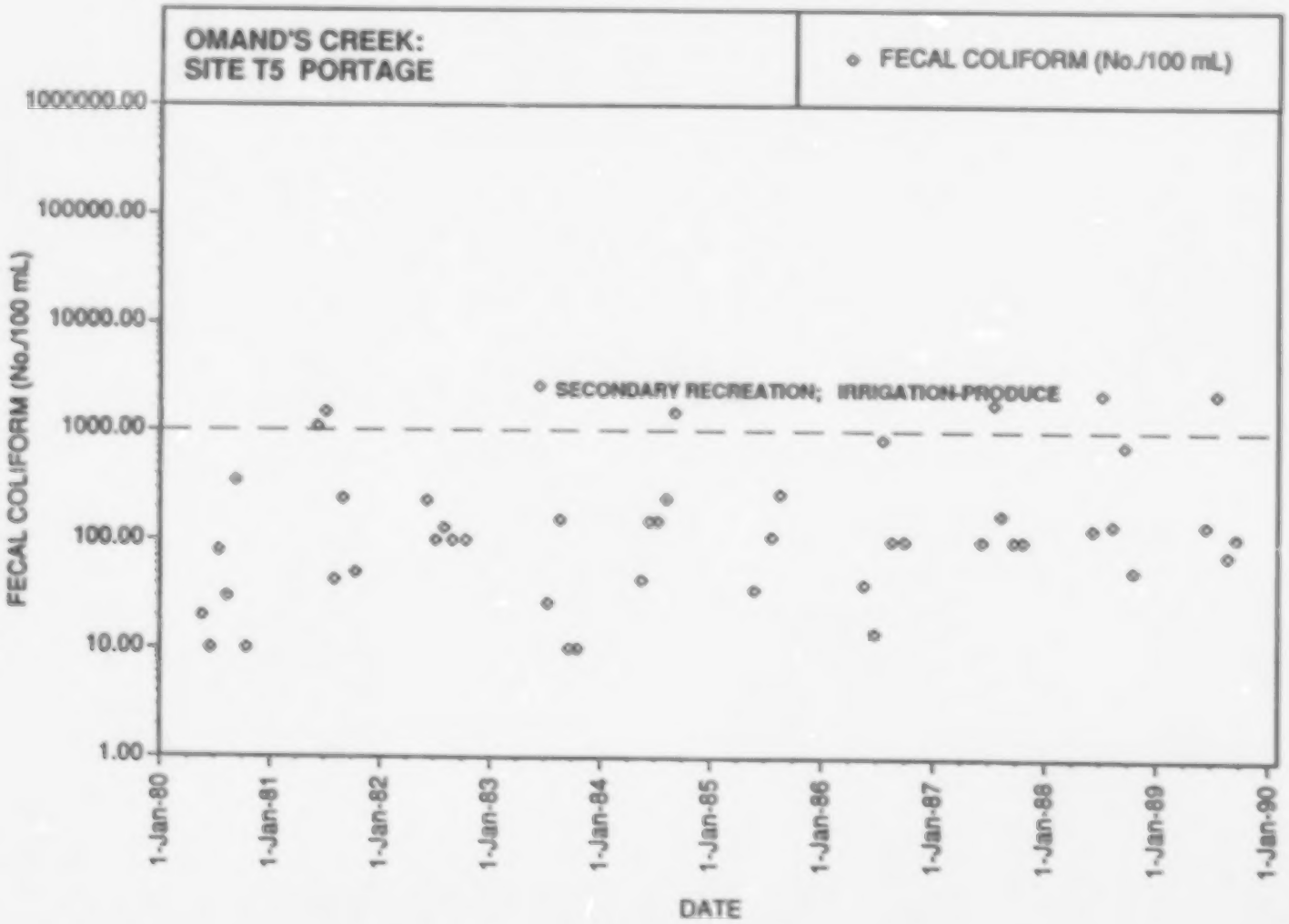


FIGURE A180: Fecal coliform concentrations in the La Salle River, at site T6 at Highway #75.

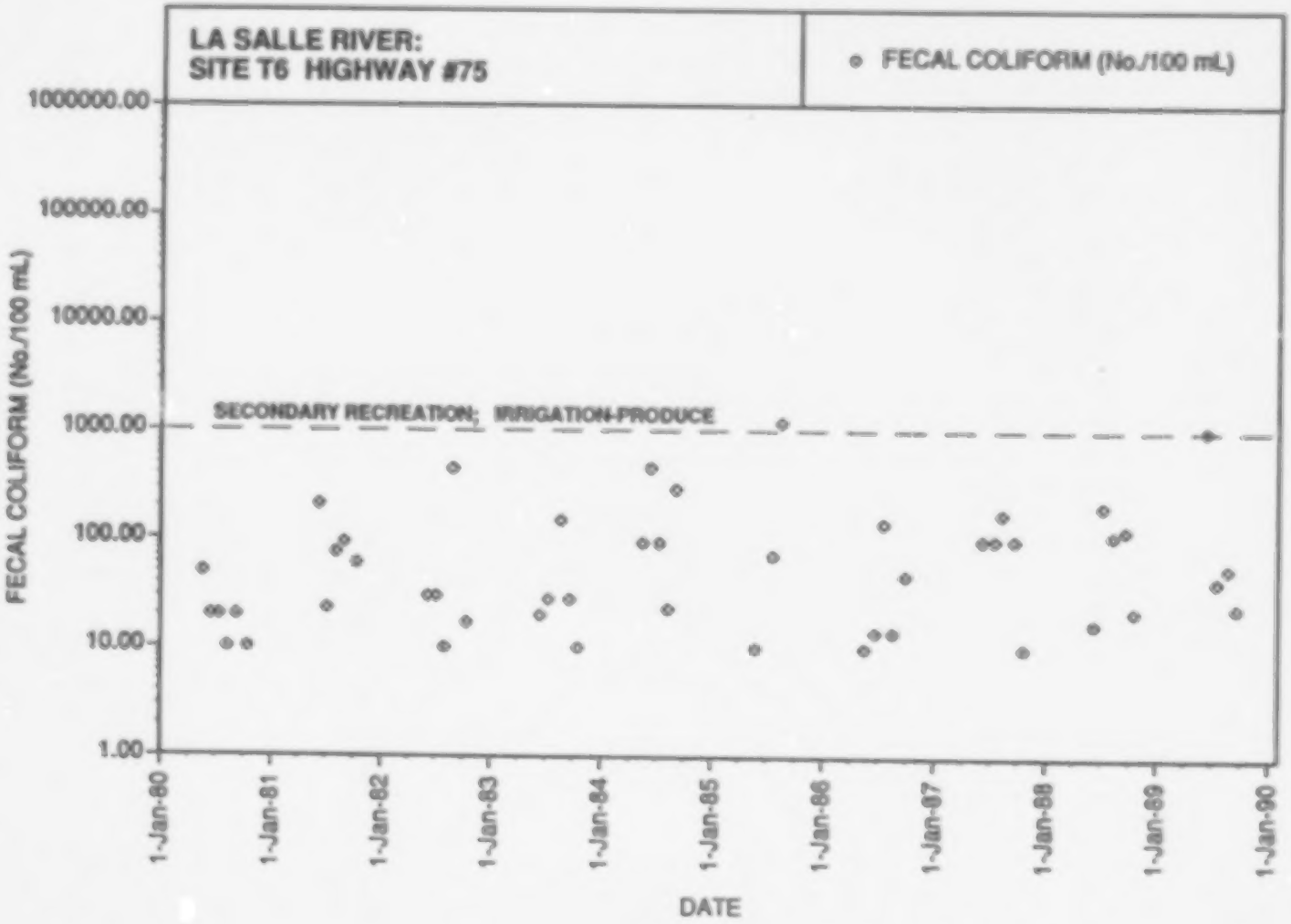


FIGURE A181: Fecal coliform concentrations in Bunn's Creek, at site T7 at Henderson Highway.

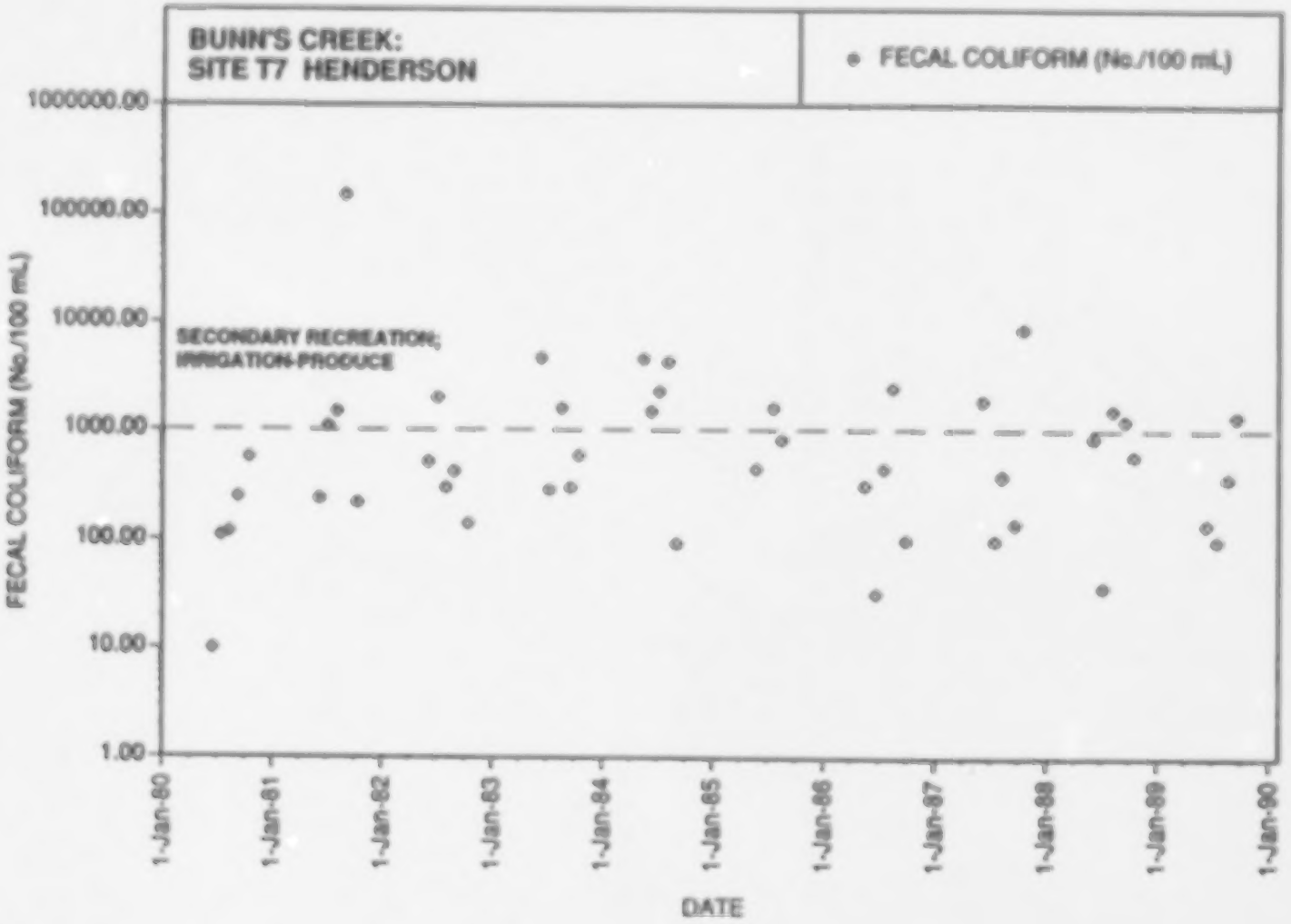


TABLE 97: Summary statistics and exceedences of the fecal coliform objective for secondary recreation and irrigation use, for the tributaries.

PARAMETER: FECAL COLIFORM [MF]
MSWQO CLASSIFICATION: SECONDARY RECREATION; IRRIGATION-PRODUCE
OBJECTIVE: 1000 (No./100 mL)

MAY-OCTOBER:1980-1989 DATA

SITE	GEOMETRIC MEAN	ARITHMETIC MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	111	187	10	1100	216	48	1	2%	1100
T2-SEINE RIVER -PROVENCHER	138	281	10	1500	365	48	4	8%	1200
T3-STURGEON CREEK -PERIMETER	54	160	4	2362	375	48	2	4%	1731
T4-STURGEON CREEK -PORTAGE	397	2485	10	24000	5329	48	14	29%	7804
T5-OMAND'S CREEK -PORTAGE	127	389	10	2600	661	48	7	15%	1858
T6-LA SALLE RIVER -HWY #75	50	124	10	1200	232	48	2	4%	1115
T7-BUNNS CREEK -HENDERSON	529	4205	10	150000	21551	48	17	35%	11321

TABLE A98: Trend analysis results for the fecal coliform concentrations in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	R2	P		TREND	N
T1-SEINE RIVER - HWY #59	0.00	0.727	N/S	INCREASING	57
T2-SEINE RIVER - PROVENCHER	0.03	0.233	N/S	INCREASING	57
T3-STURGEON CREEK - PERIMETER	0.03	0.224	N/S	INCREASING	57
T4-STURGEON CREEK - PORTAGE	0.00	0.758	N/S	DECREASING	57
T5-OMAND'S CREEK - PORTAGE	0.03	0.186	N/S	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.01	0.481	N/S	INCREASING	57
T7-BUNNS CREEK - HENDERSON	0.01	0.567	N/S	INCREASING	57

* indicates significance level at P<0.05
** indicates signifcance level of P<0.01
N/S indicates no significant trend (P>0.05)
N refers to the sample size

FIGURE A182: Turbidity levels in the Seine River at site T1 at Highway #59.

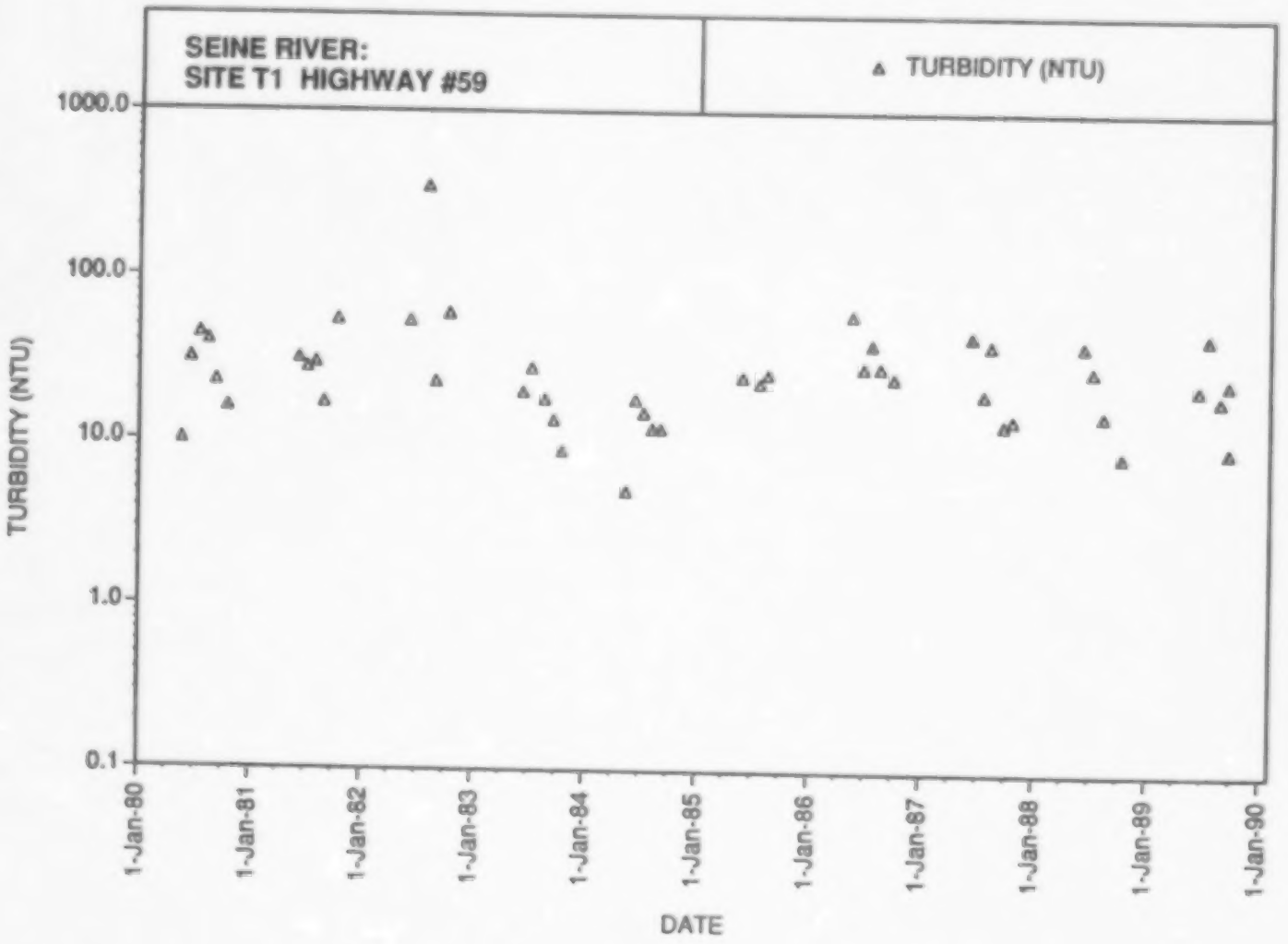


FIGURE A183: Turbidity levels in the Seine River, at site T2 at the Provencher Street Bridge.

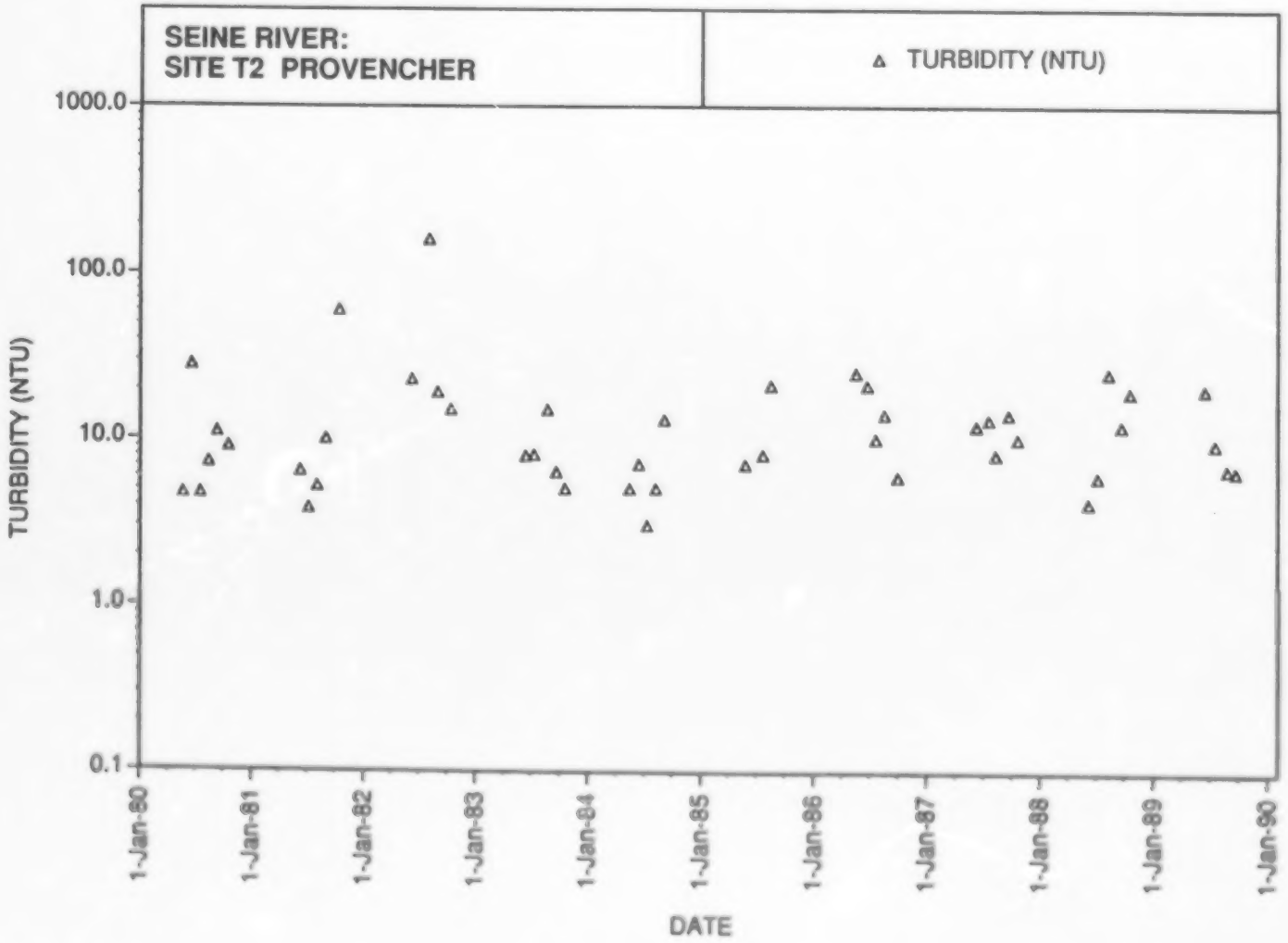


FIGURE A184: Turbidity levels in Sturgeon Creek, at site T3 at the perimeter.

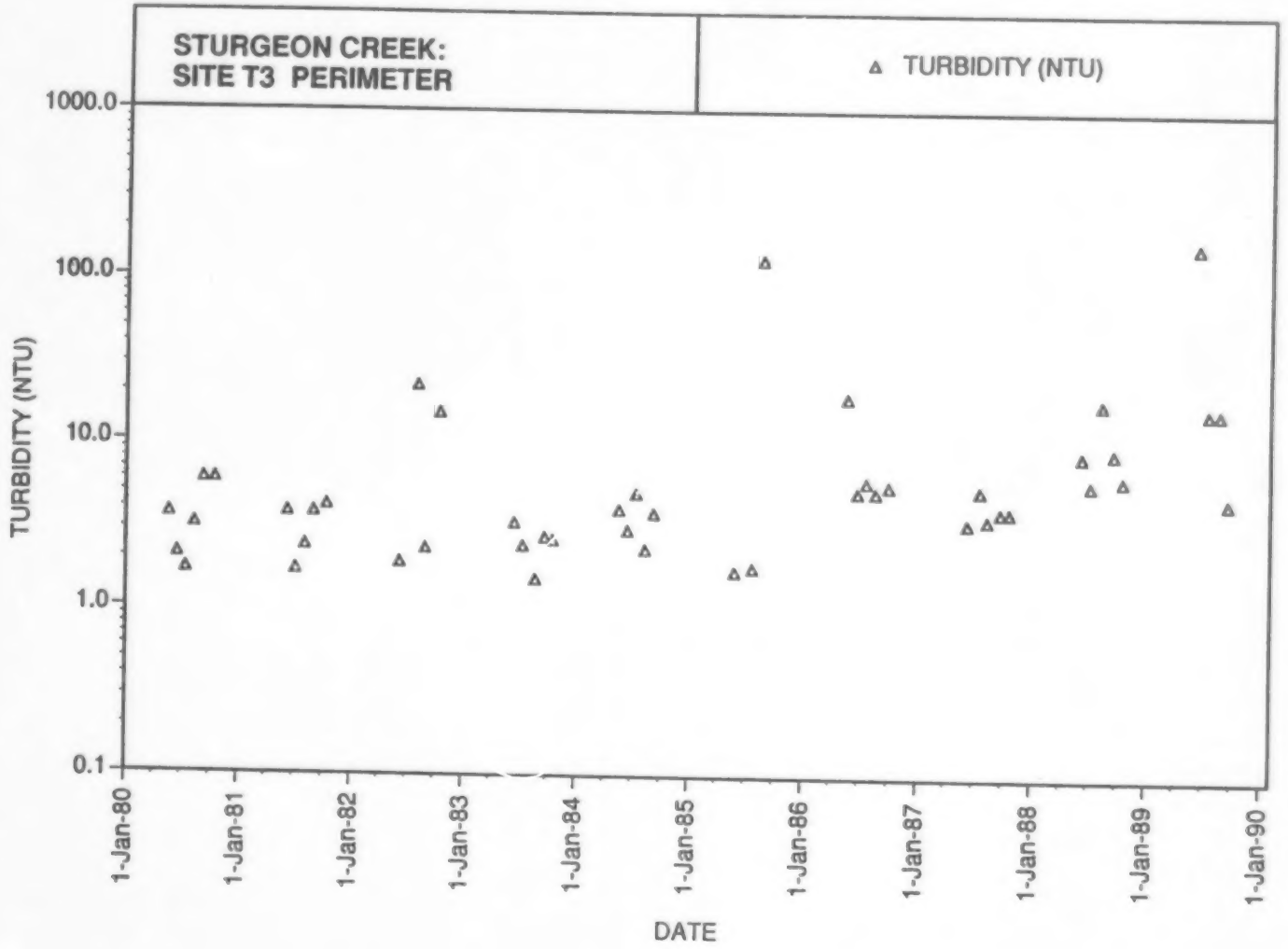


FIGURE A185: Turbidity levels in Sturgeon Creek, at site T4 at Portage Avenue.

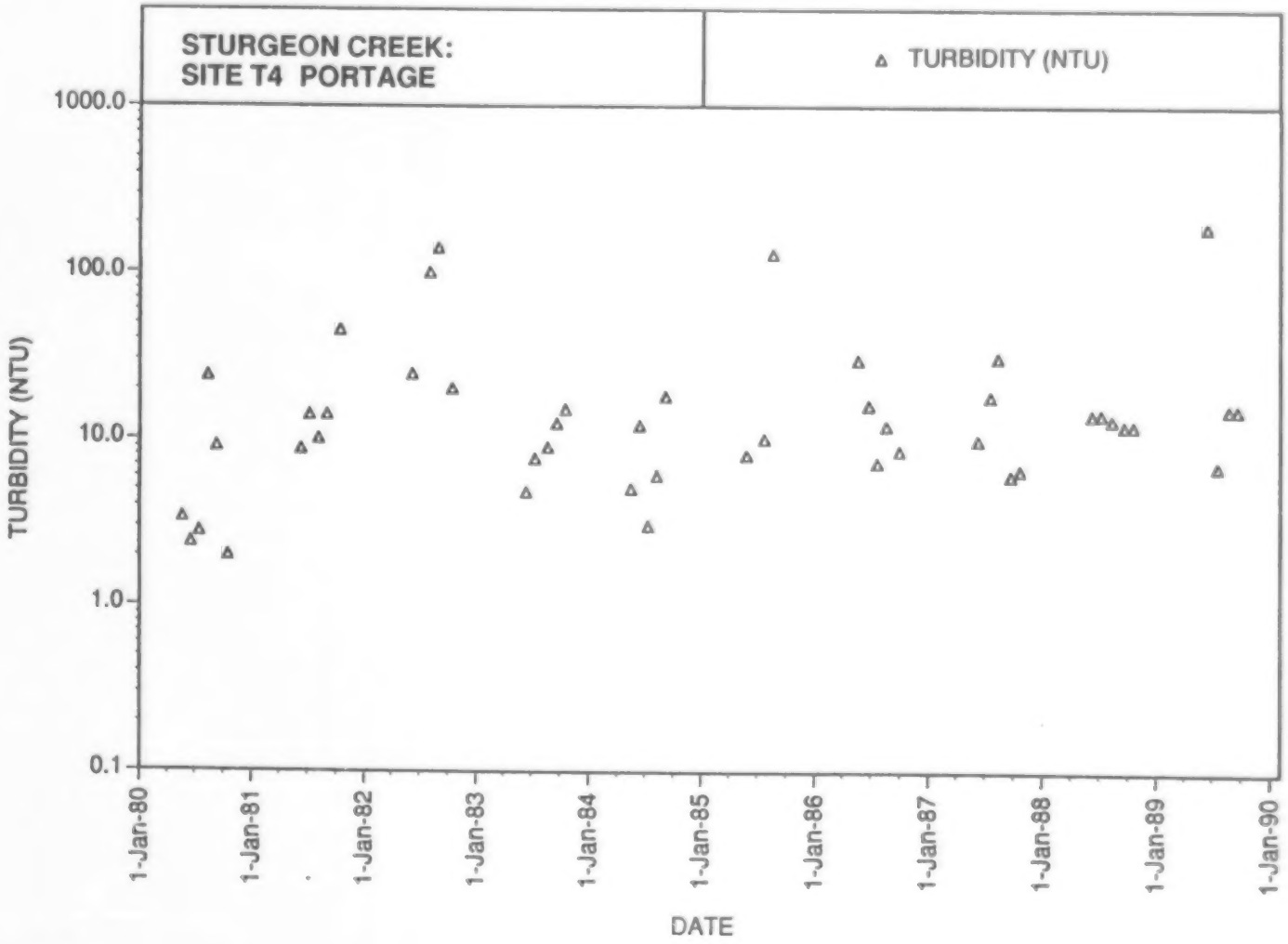


FIGURE A186: Turbidity levels in Omand's Creek, at site T5 at Portage Avenue.

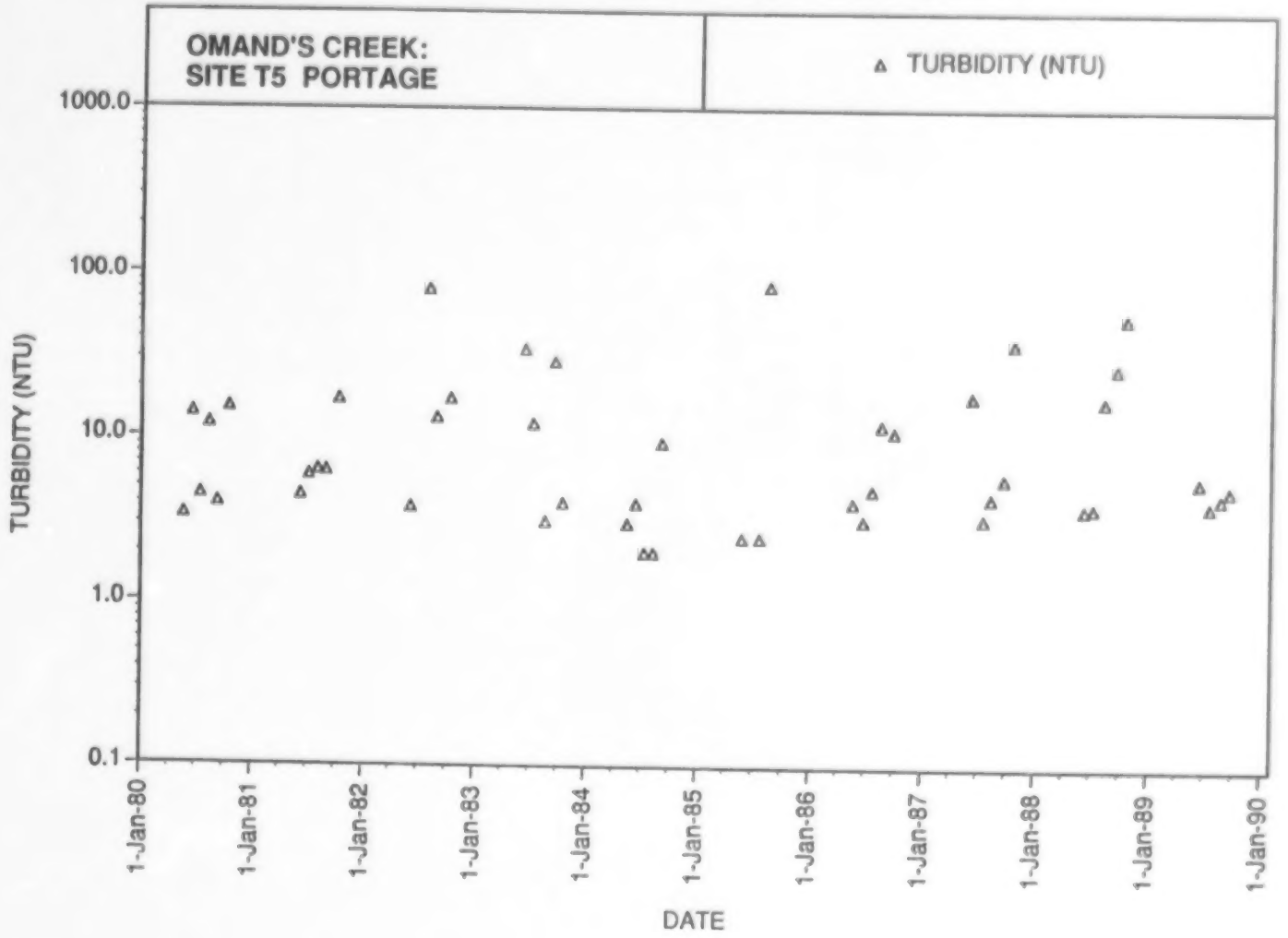


FIGURE A187: Turbidity levels in the La Salle River, at site T6 at Highway #75.

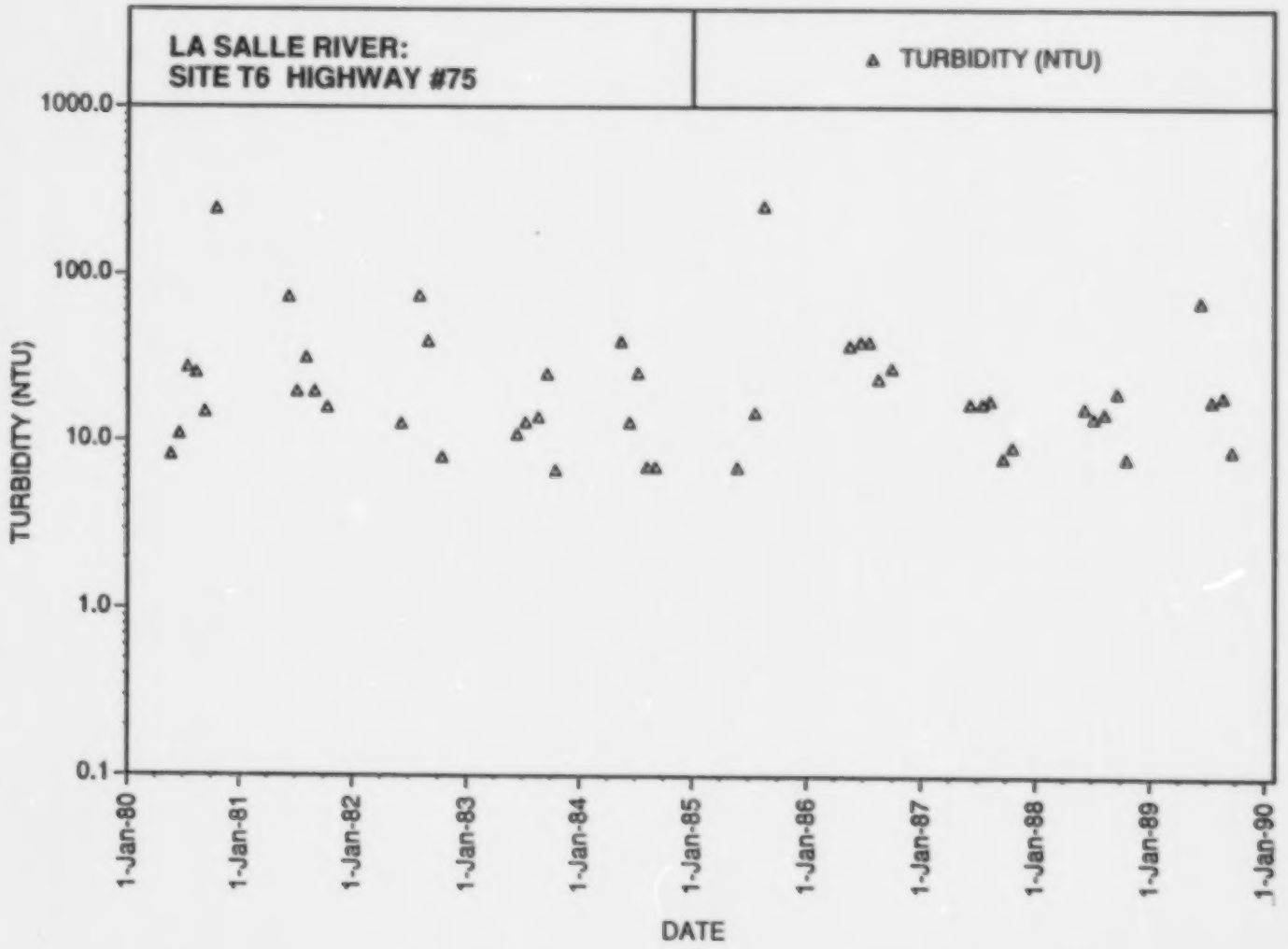


FIGURE A188: Turbidity levels in Bunn's Creek, at site T7 at Henderson Highway.

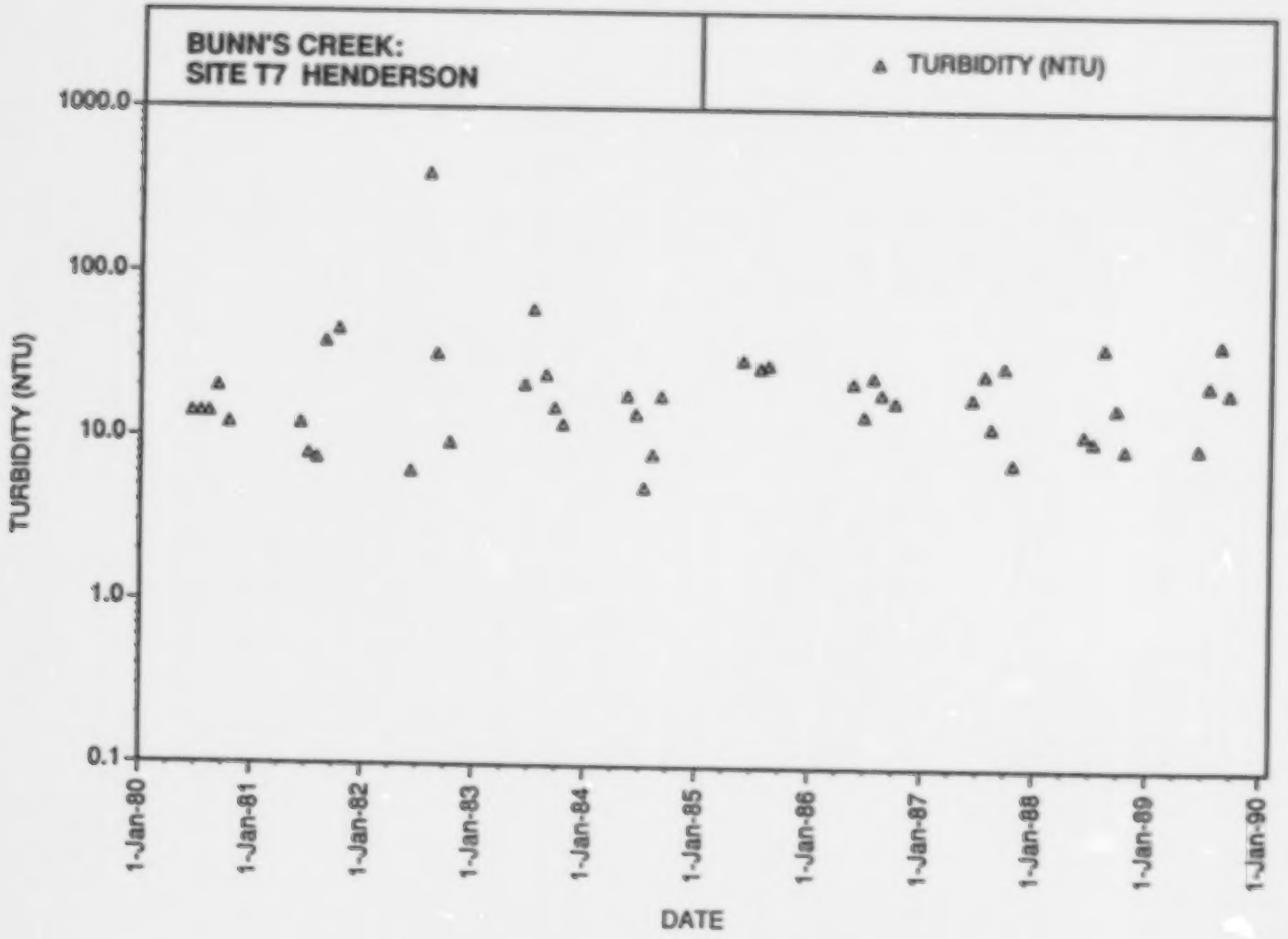


TABLE A99: Summary statistics for the turbidity data in the tributaries.

PARAMETER: TURBIDITY (NTU)
MSWQO CLASSIFICATION: NOT APPLICABLE
OBJECTIVE: NONE

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	33.3	5.0	350.0	49.3	47	N/A		
T2-SEINE RIVER -PROVENCHER	15.3	3.0	160.0	23.6	47	N/A		
T3-STURGEON CREEK -PERIMETER	11.7	1.5	160.0	29.0	47	N/A		
T4-STURGEON CREEK -PORTAGE	23.4	2.0	190.0	38.1	47	N/A		
T5-OMAND'S CREEK -PORTAGE	13.4	2.0	85.0	18.2	47	N/A		
T6-LA SALLE RIVER -HWY #75	32.1	6.7	260.0	50.3	47	N/A		
T7-BUNNS CREEK -HENDERSON	27.3	5.0	400.0	56.7	47	N/A		

N/A = Not Applicable

TABLE A100: Trend analysis results for the turbidity data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	R2	P		TREND	N
T1-SEINE RIVER - HWY #59	0.01	0.467	N/S	DECREASING	57
T2-SEINE RIVER - PROVENCHER	0.00	0.681	N/S	DECREASING	57
T3-STURGEON CREEK - PERIMETER	0.03	0.201	N/S	INCREASING	57
T4-STURGEON CREEK - PORTAGE	0.01	0.375	N/S	INCREASING	57
T5-OMAND'S CREEK - PORTAGE	0.02	0.258	N/S	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.01	0.583	N/S	DECREASING	57
T7-BUNNS CREEK - HENDERSON	0.00	0.801	N/S	DECREASING	57

* indicates significance level at $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend ($P>0.05$)
N refers to the sample size

FIGURE A189: Conductivity levels in the Seine River, at site T1 at Highway #59.

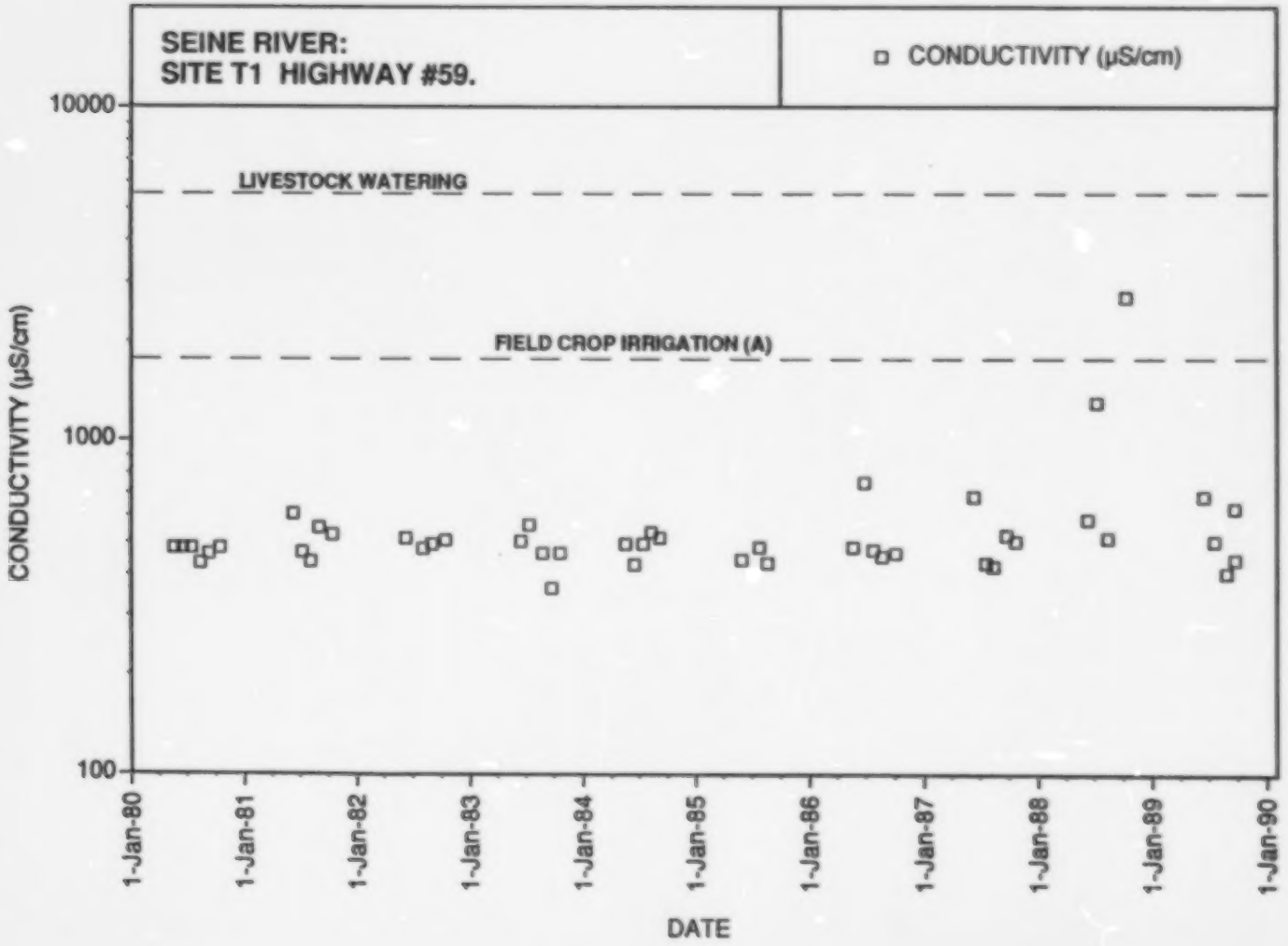


FIGURE A190: Conductivity levels in the Seine River, at site T2 at the Provencher Street Bridge.

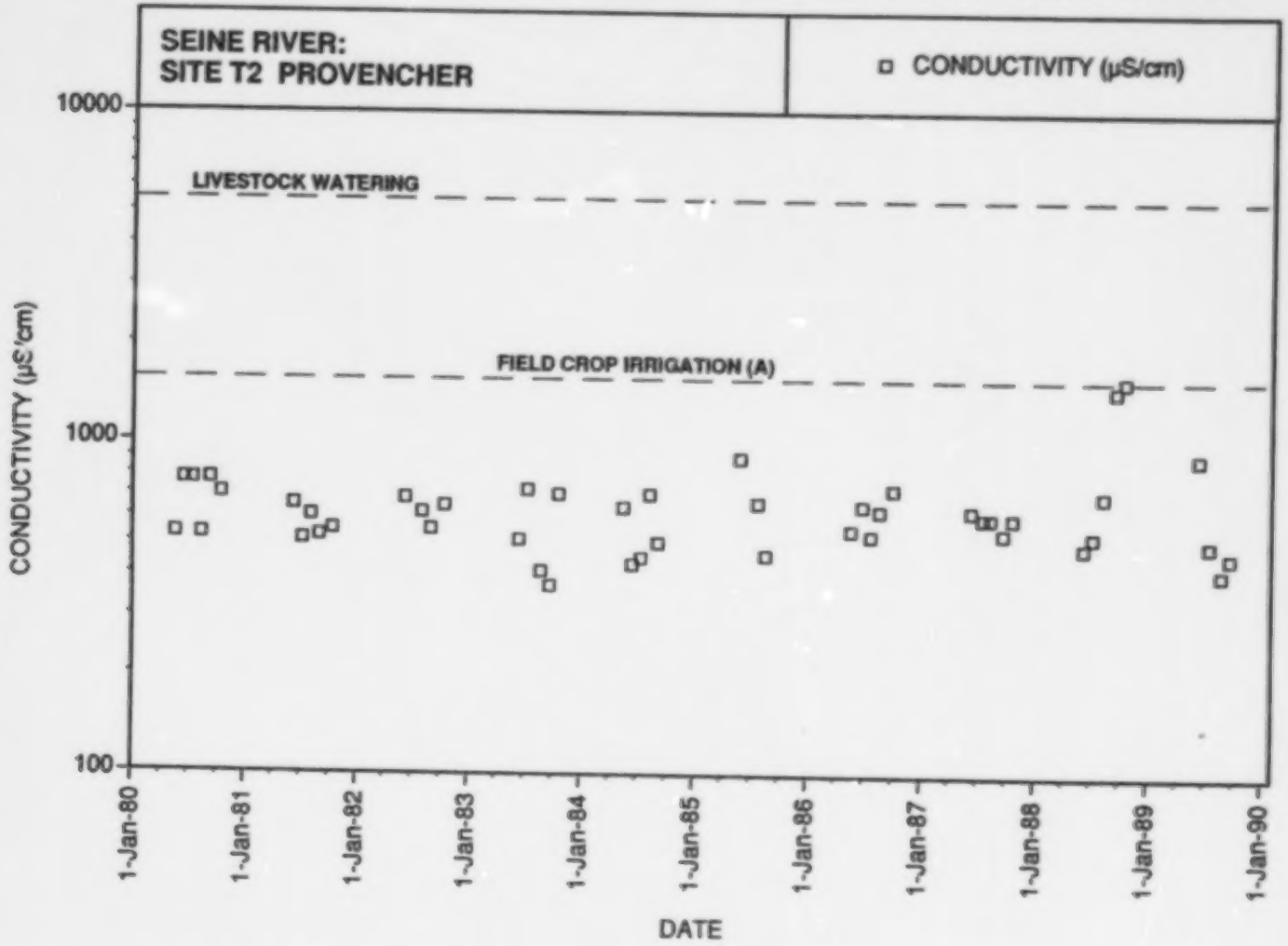


FIGURE A191: Conductivity levels in Sturgeon Creek, at site T3 at the perimeter.

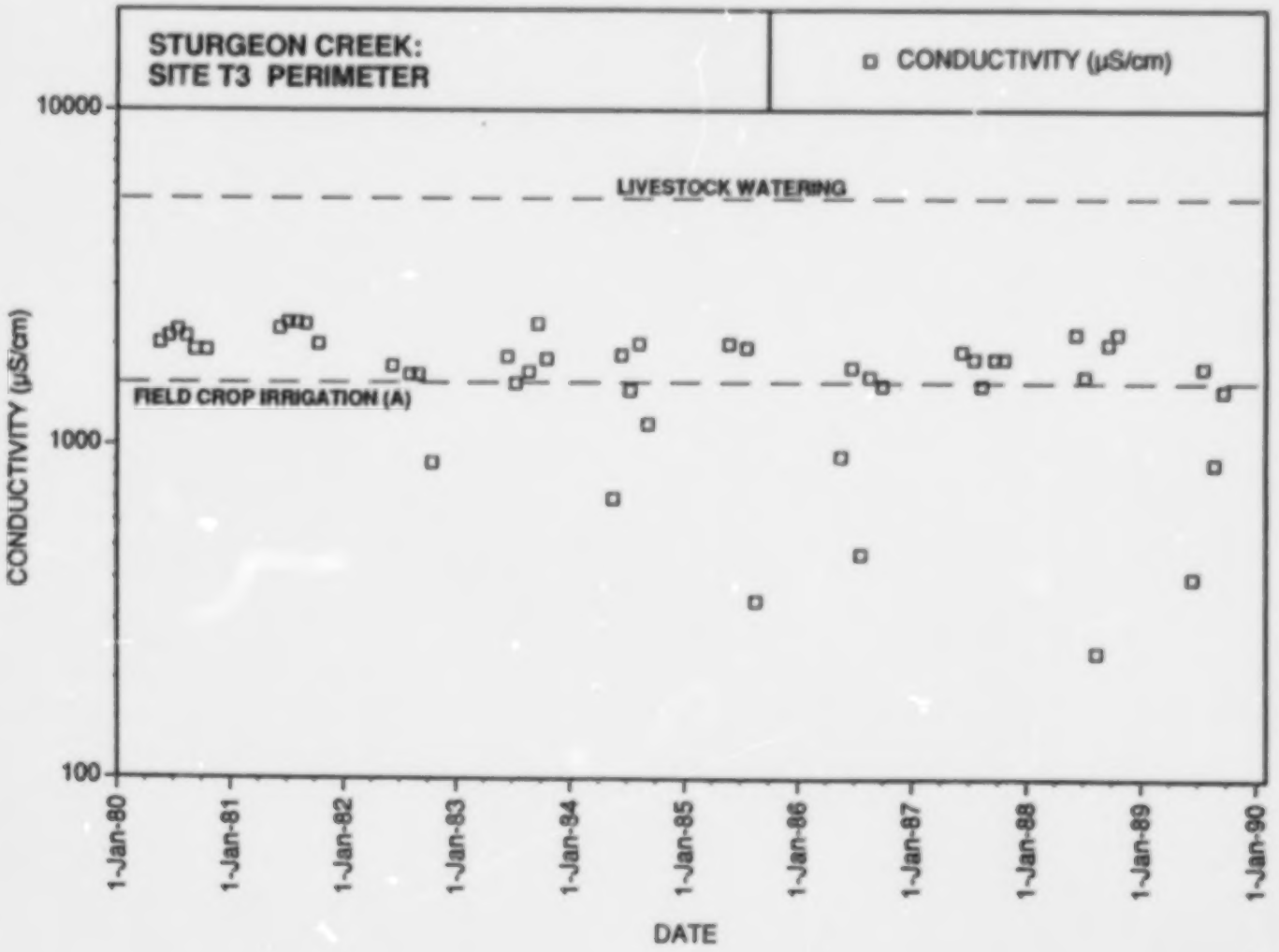


FIGURE A192: Conductivity levels in Sturgeon Creek, at site T4 at Portage Avenue.

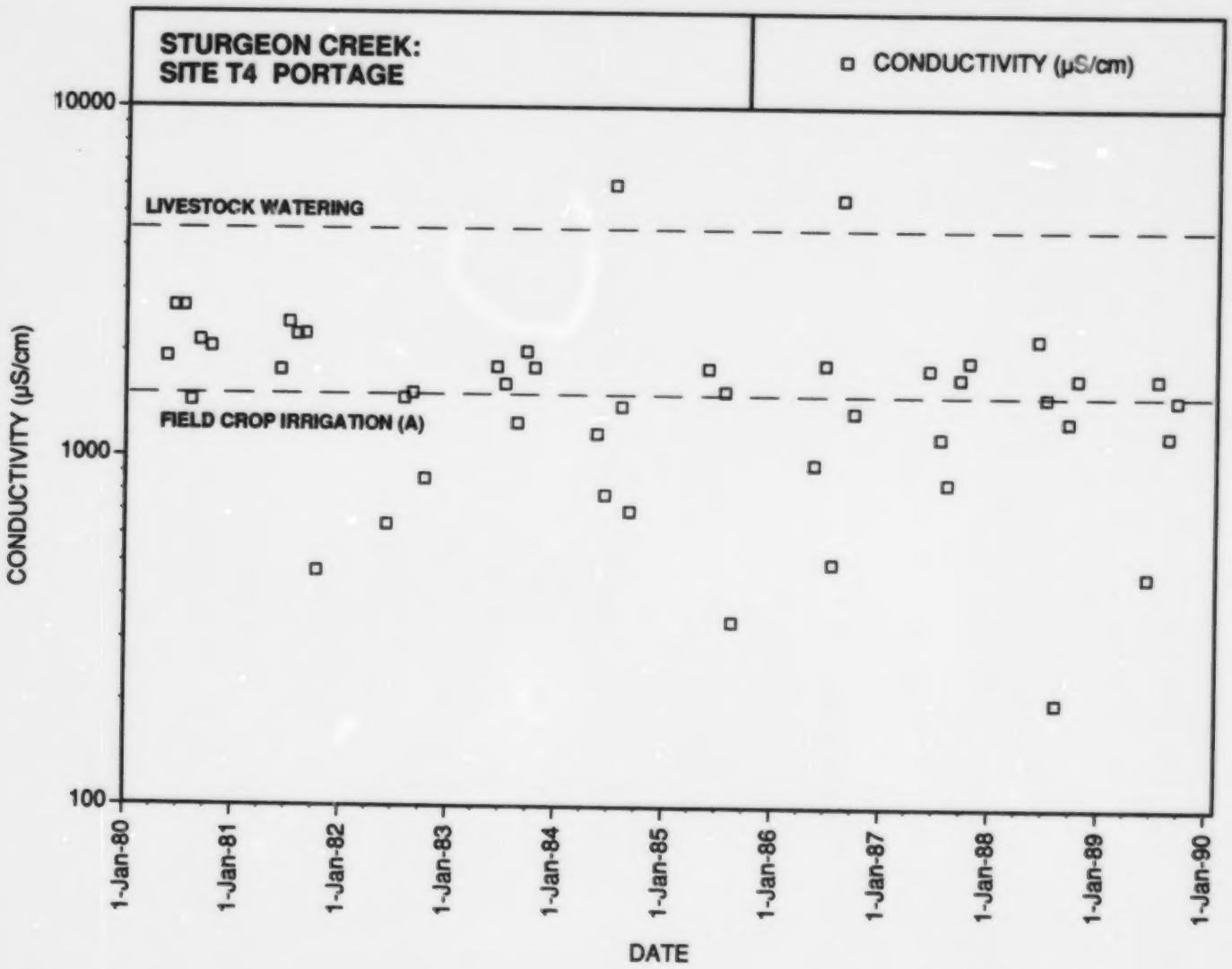


FIGURE A193: Conductivity levels in Omand's Creek, at site T5 at Portage Avenue.

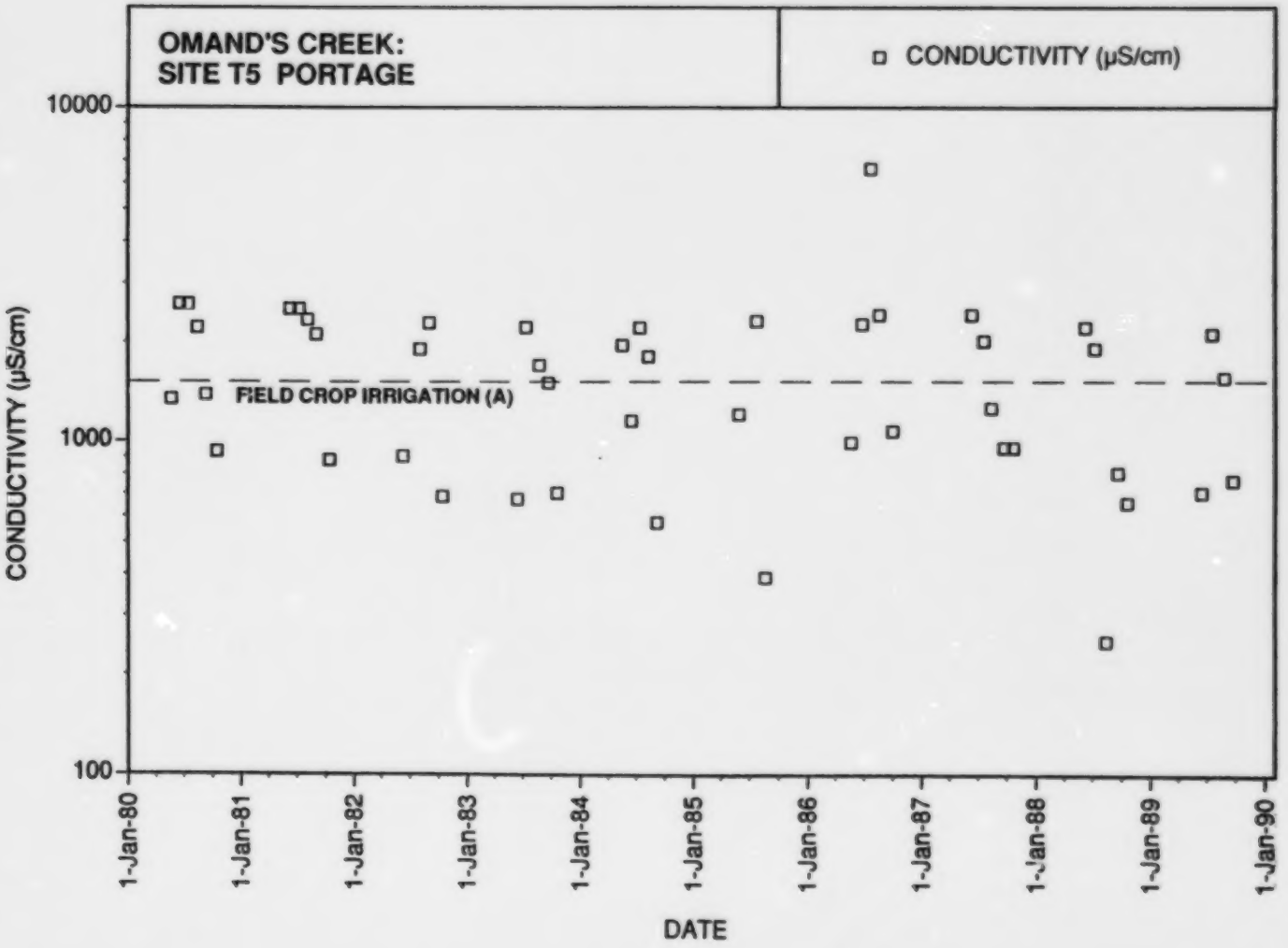


FIGURE A194: Conductivity levels in the La Salle River, at site T6 at Highway #75.

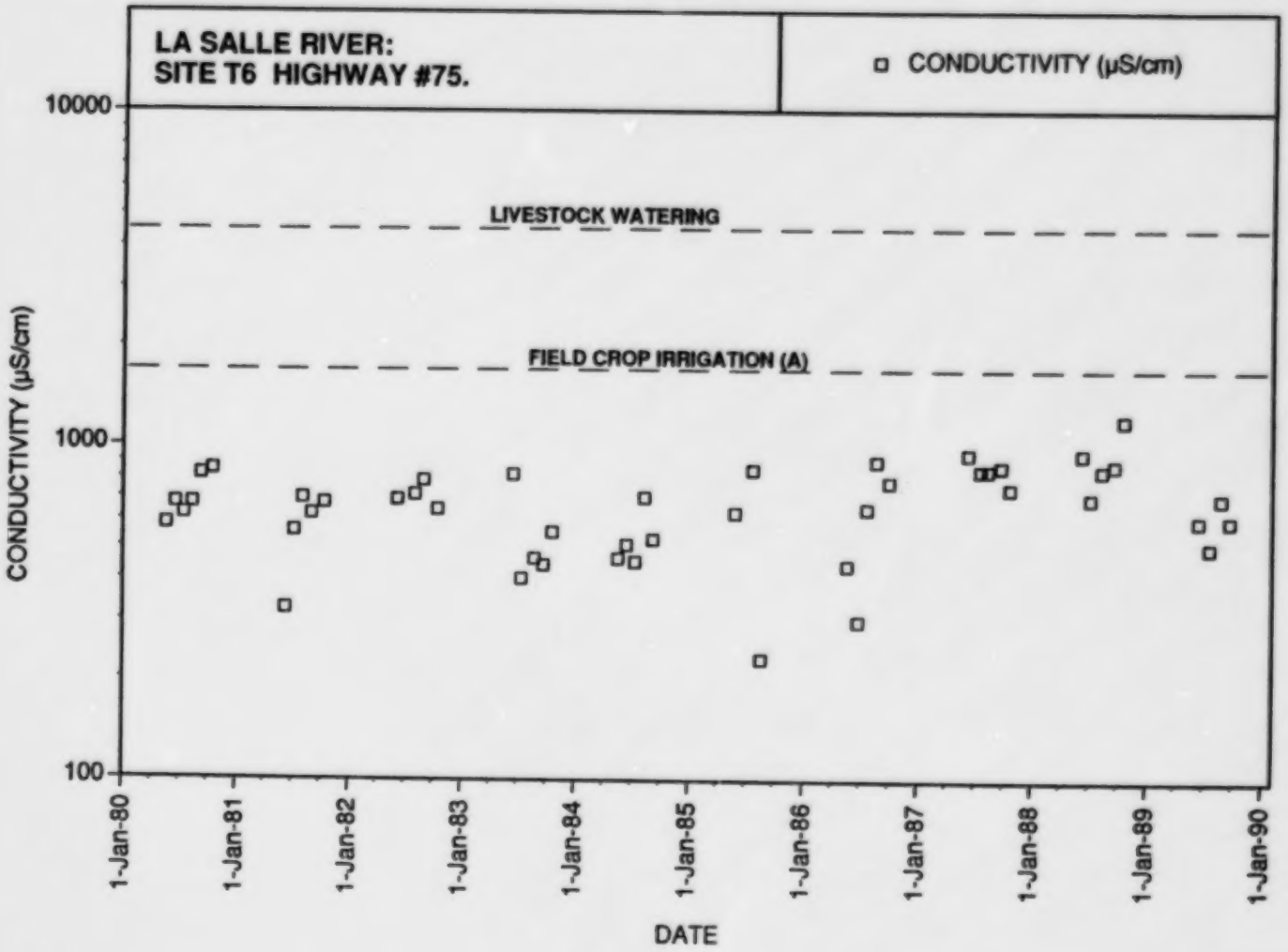


FIGURE A195: Conductivity levels in Bunn's Creek, at site T7 at Henderson Highway.

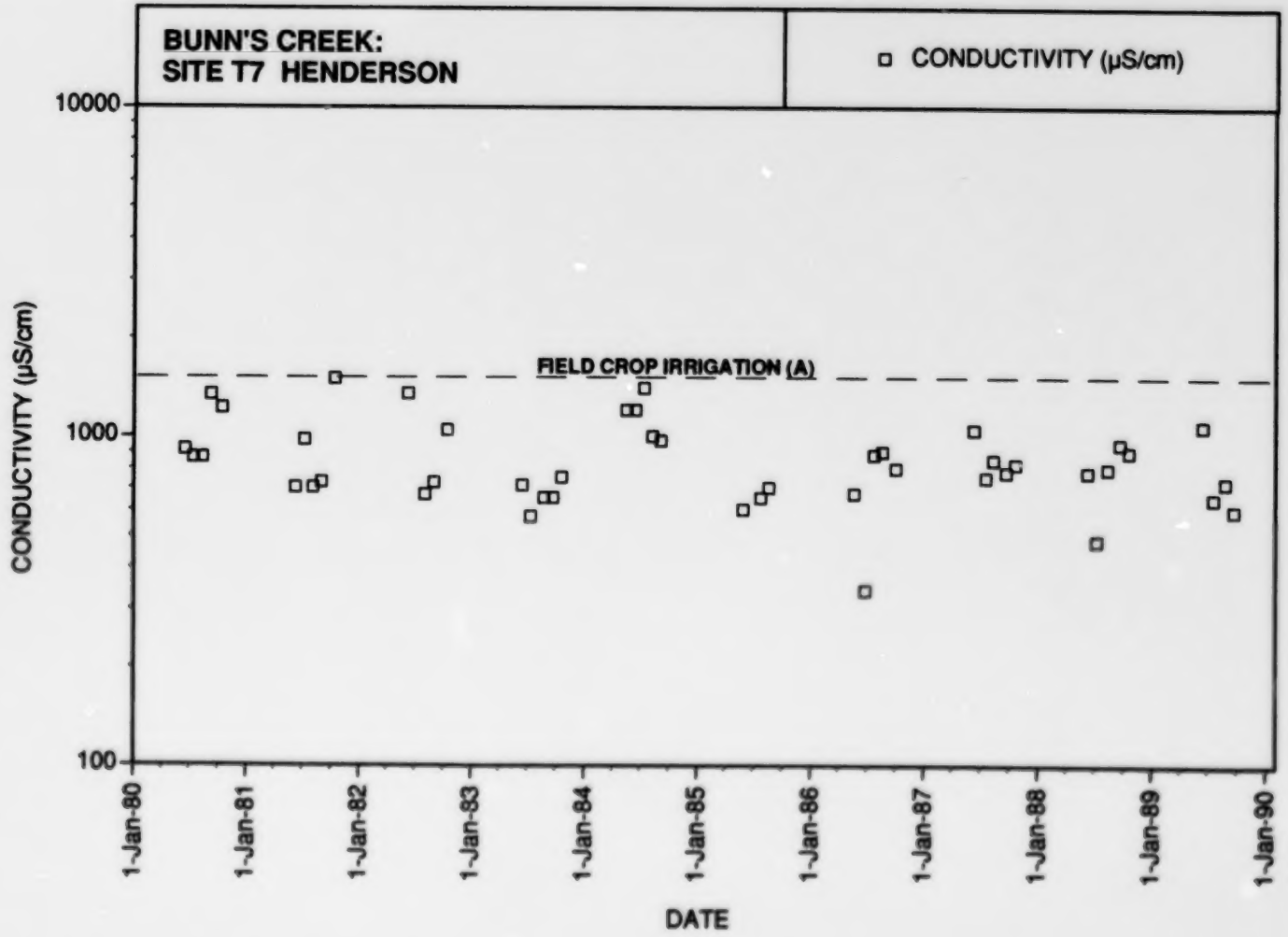


TABLE A101: Summary statistics and exceedences of the conductivity objective, for field crop irrigation in the tributaries.

PARAMETER: CONDUCTIVITY
MSWQO CLASSIFICATION: FIELD CROP IRRIGATION(A)
OBJECTIVE: 1500 (µS/cm)

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	562	360	2700	347	47	1	2%	2700
T2-SEINE RIVER -PROVENCHER	636	370	1550	220	47	1	2%	1550
T3-STURGEON CREEK -PERIMETER	1647	240	2325	554	47	34	72%	1927
T4-STURGEON CREEK -PORTAGE	1660	200	6000	1063	47	25	53%	2264
T5-OMAND'S CREEK -PORTAGE	1643	250	6600	1018	47	24	51%	2357
T6-LA SALLE RIVER -HWY #75	666	230	1200	193	47	0	0%	
T7-BUNNS CREEK -HENDERSON	862	340	1500	248	47	0	0%	

TABLE A102: Summary statistics and exceedences of the conductivity objective, for livestock watering in the tributaries.

PARAMETER: CONDUCTIVITY
MSWQO CLASSIFICATION: LIVESTOCK WATERING
OBJECTIVE: 4300 (µS/cm)

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	562	360	2700	347	47	0	0.%	
T2-SEINE RIVER -PROVENCHER	636	370	1550	220	47	0	0.%	
T3-STURGEON CREEK -PERIMETER	1647	240	2325	554	47	0	0.%	
T4-STURGEON CREEK -PORTAGE	1660	200	6000	1063	47	2	4.%	5750
T5-OMAND'S CREEK -PORTAGE	N/A							
T6-LA SALLE RIVER -HWY #75	666	230	1200	193	47	0	0.%	
T7-BUNNS CREEK -HENDERSON	N/A							

N/A = Classification not applicable

TABLE A103: Trend analysis results for conductivity data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	**R2**	**P**		**TREND**	**N**
T1-SEINE RIVER - HWY #59	0.07	0.043	*	INCREASING	57
T2-SEINE RIVER - PROVENCHER	0.05	0.098	N/S	INCREASING	57
T3-STURGEON CREEK - PERIMETER	0.08	0.032	*	DECREASING	57
T4-STURGEON CREEK - PORTAGE	0.02	0.303	N/S	DECREASING	57
T5-OMAND'S CREEK - PORTAGE	0.02	0.321	N/S	DECREASING	57
T6-LA SALLE RIVER - HWY #75	0.00	0.858	N/S	INCREASING	57
T7-BUNNS CREEK - HENDERSON	0.13	0.005	**	DECREASING	57

* indicates significance level at P<0.05
** indicates signifcance level of P<0.01
N/S indicates no significant trend (P>0.05)
N refers to the sample size

FIGURE A196: Nitrate/nitrite concentrations in the Seine River at site T1 at Highway #59.

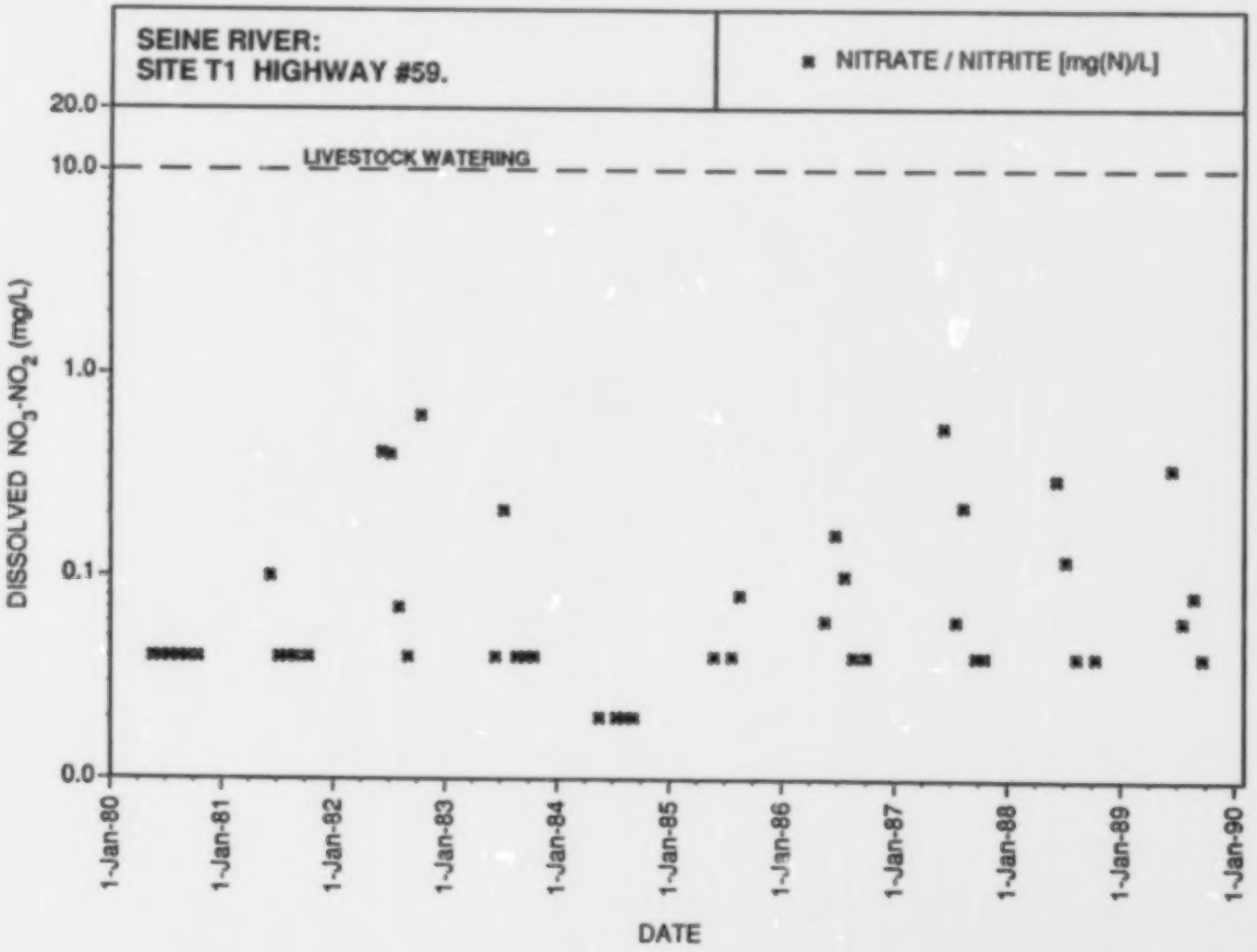


FIGURE A197: Nitrate/nitrite concentrations in the Seine River, at site T2 at the Provencher Street Bridge.

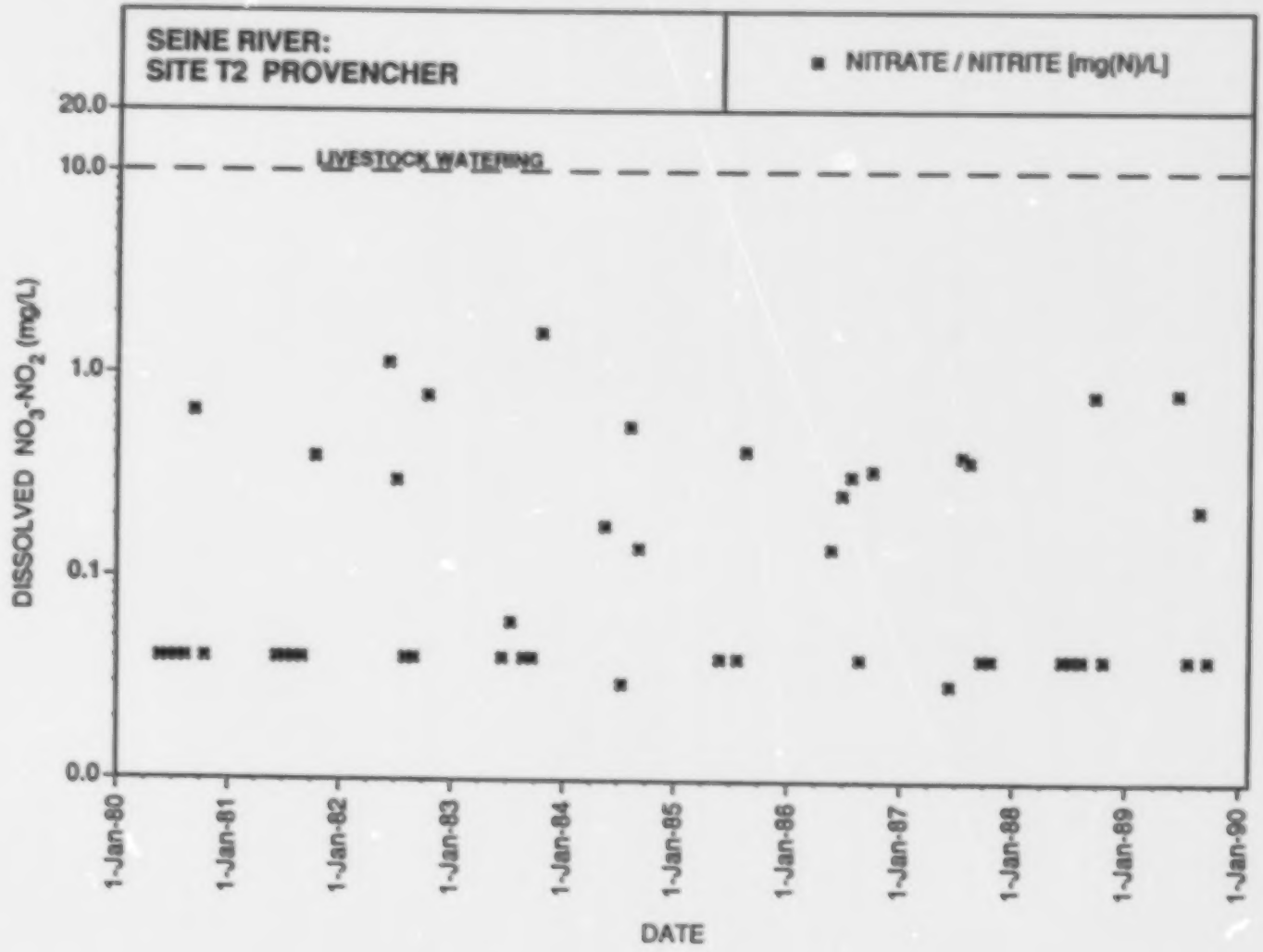


FIGURE A198: Nitrate/nitrite concentrations in Sturgeon Creek, at site T3 at the perimeter.

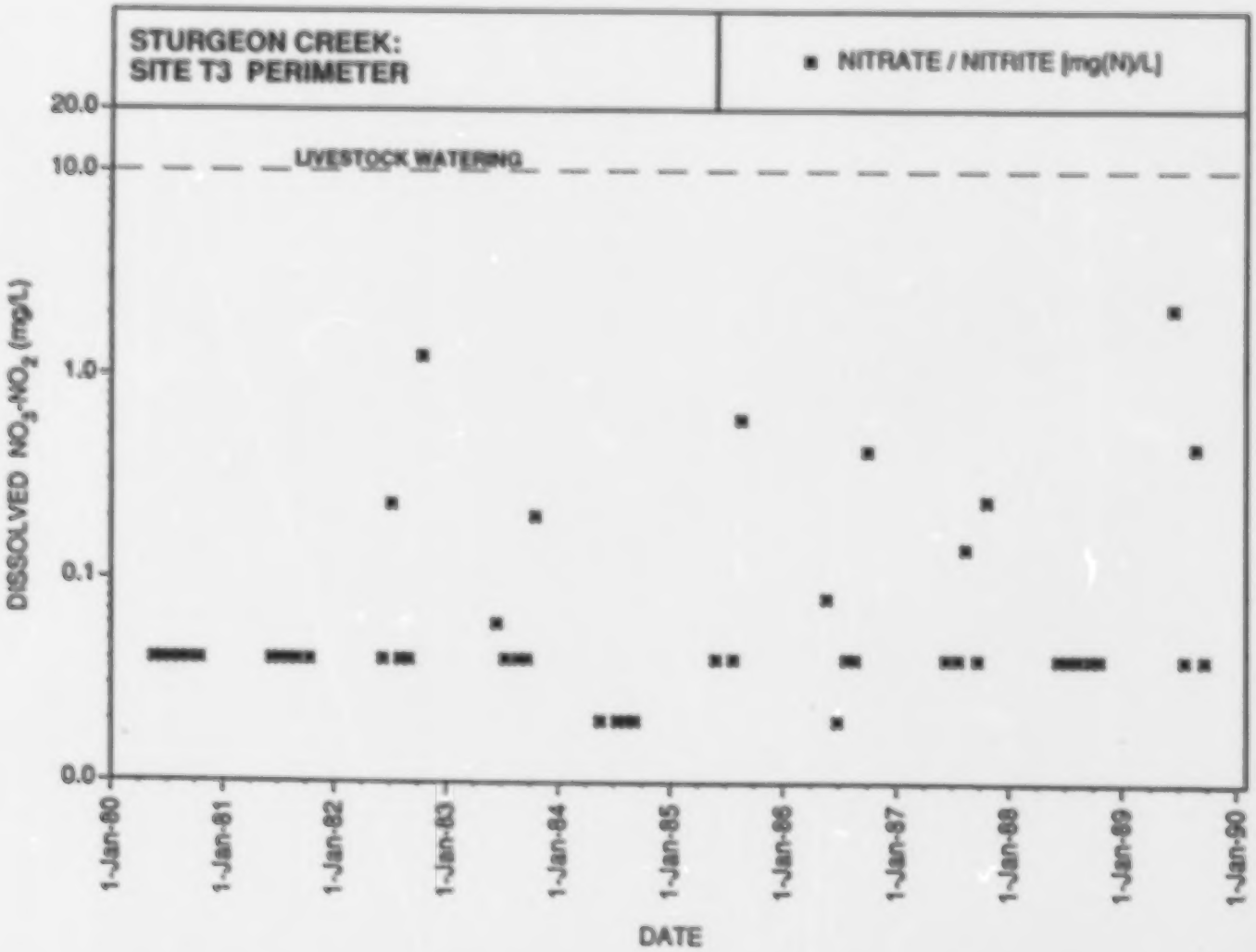


FIGURE A199: Nitrate/nitrite concentrations in Sturgeon Creek, at site T4 at Portage Avenue.

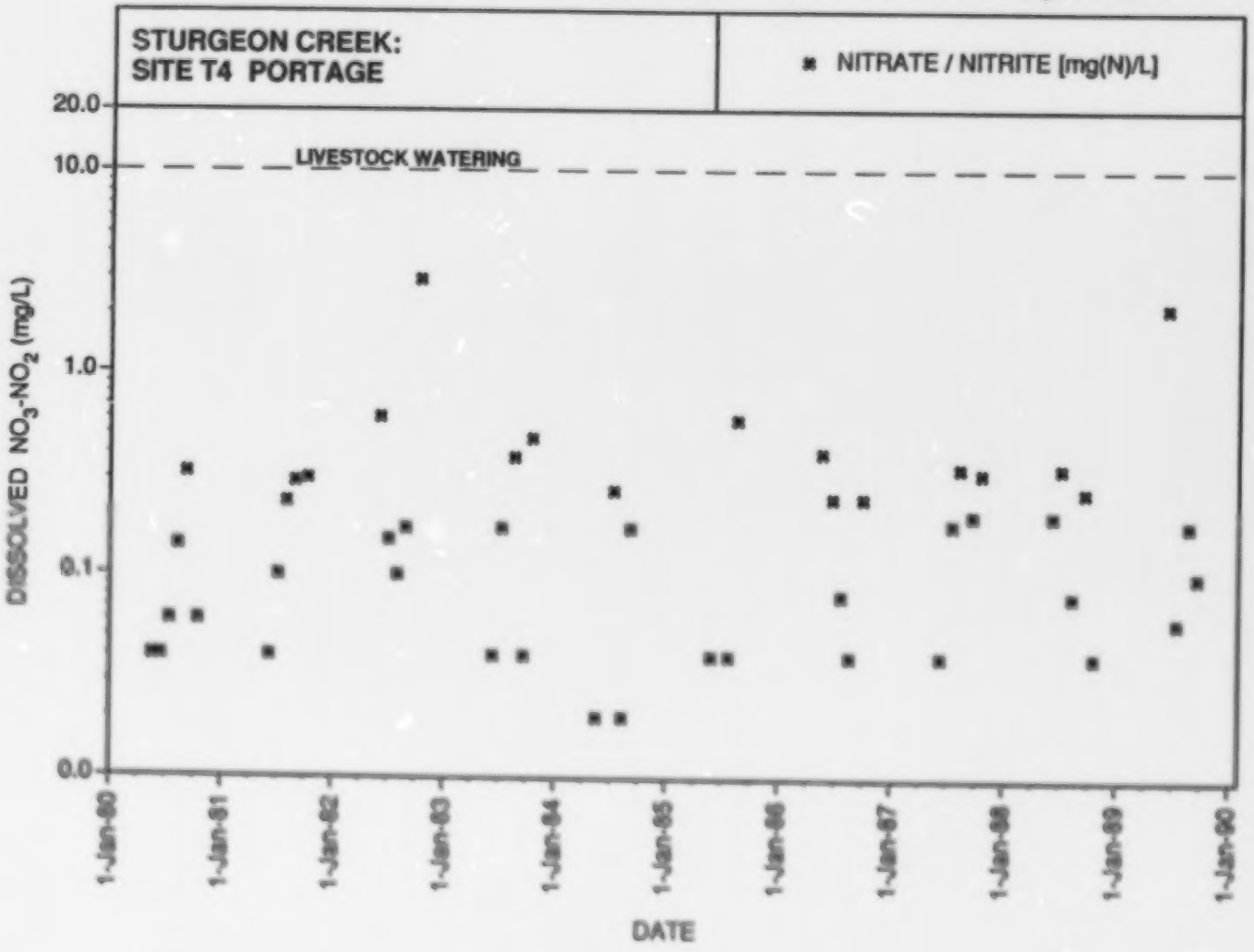


FIGURE A200: Nitrate/nitrite concentrations in Omand's Creek, at site T5 at Portage Avenue.

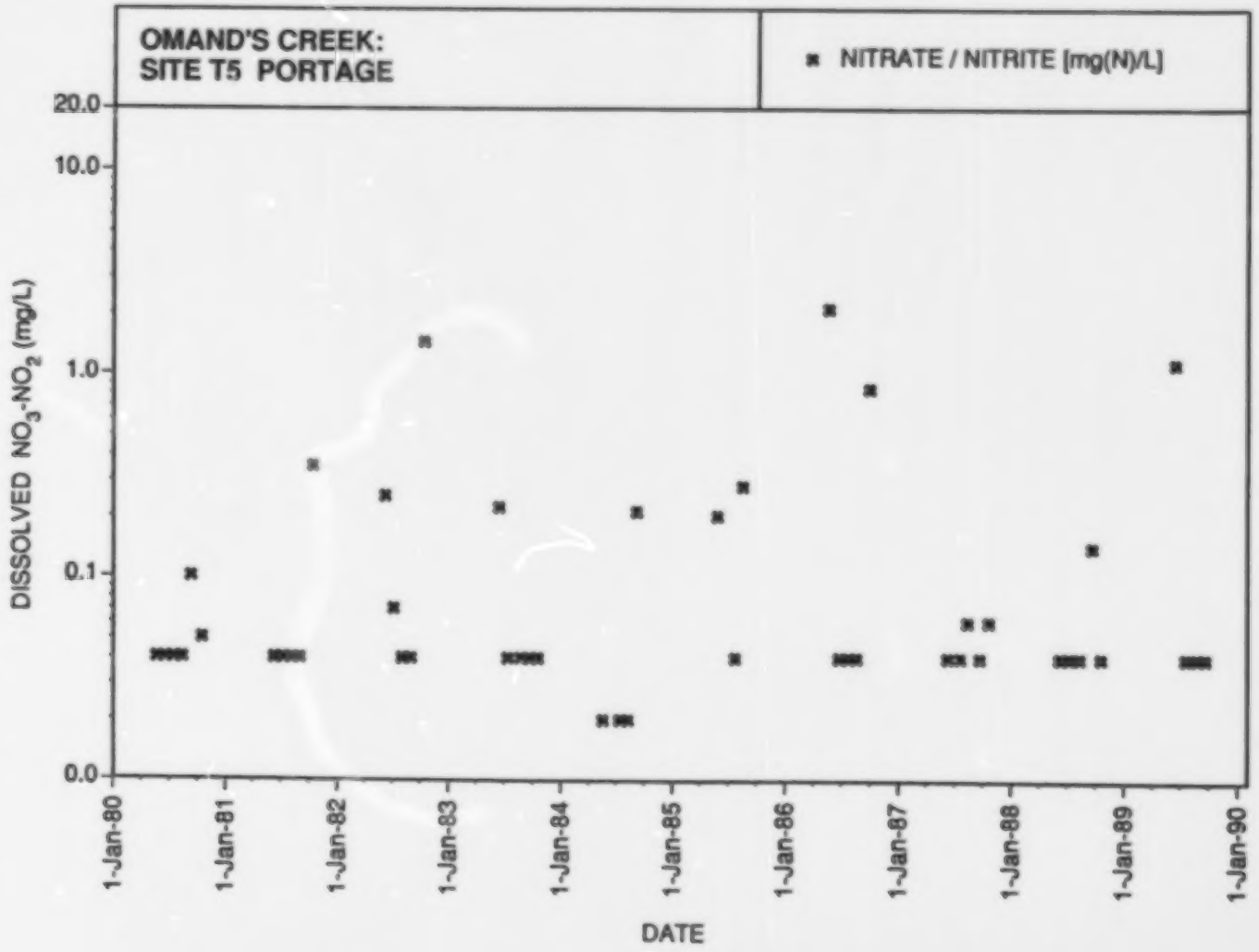


FIGURE A201: Nitrate/nitrite concentrations in the La Salle River, at site T6 at Highway #75.

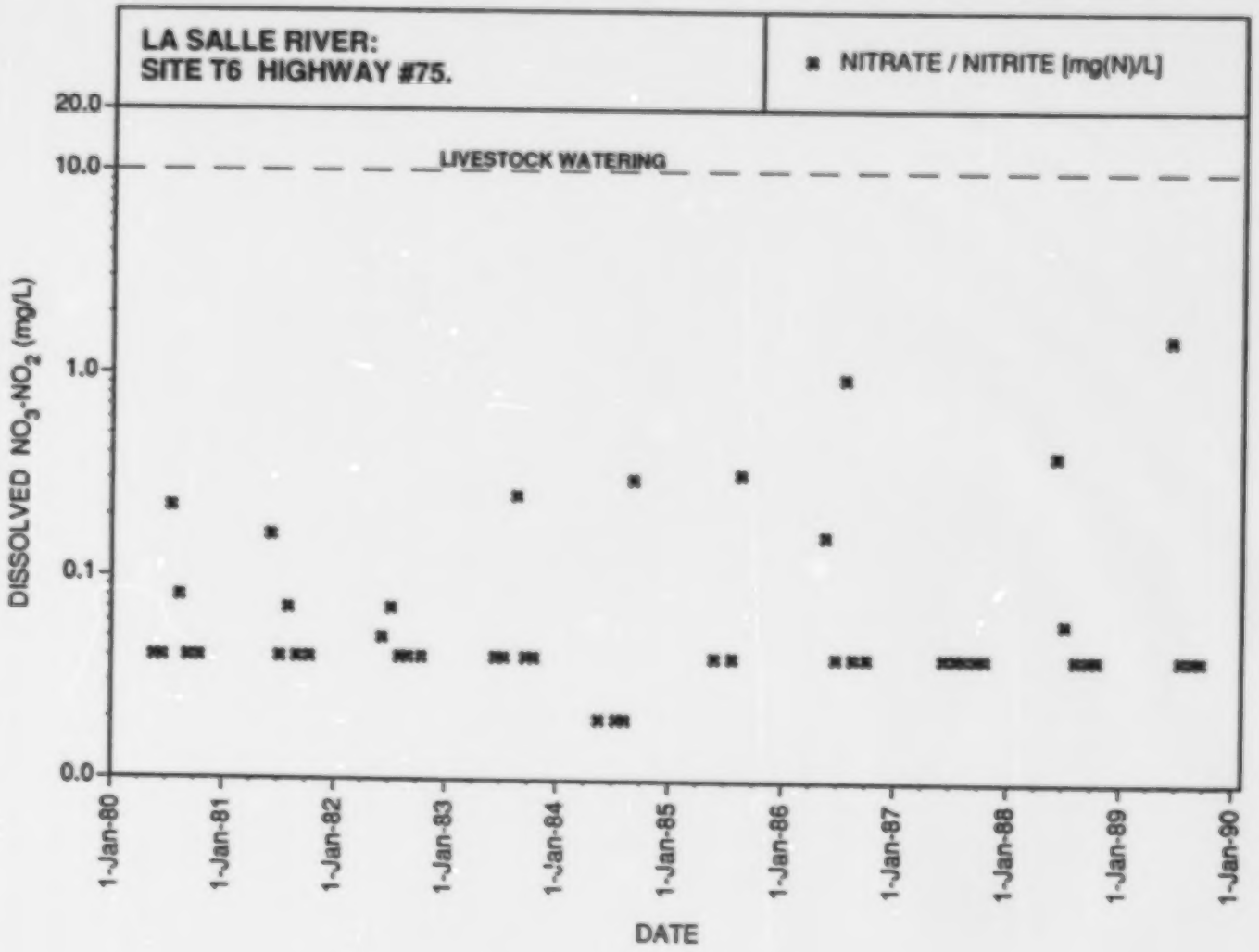


FIGURE A202: Nitrate/nitrite concentrations in Bunn's Creek at site T7 at Henderson Highway.

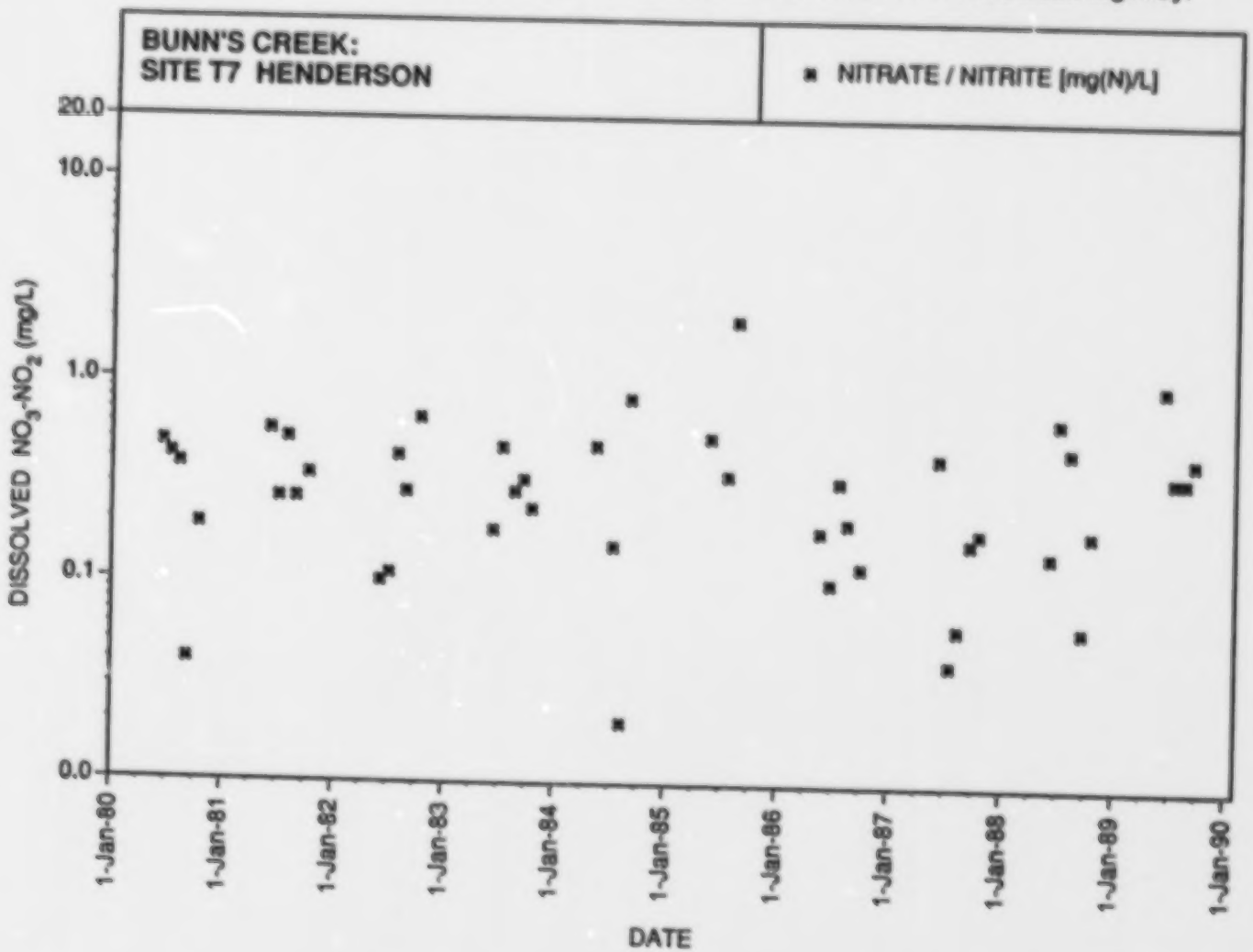


TABLE A104: Summary statistics and exceedences of the nitrate/nitrite objective, for livestock watering in the tributaries.

PARAMETER: NITRATE/NITRITE
MSWQO CLASSIFICATION: LIVESTOCK WATERING
OBJECTIVE: 10 (mg/L)

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	0.11	0.02	0.62	0.14	47	0	0.0%	
T2-SEINE RIVER -PROVENCHER	0.23	0.03	1.60	0.33	47	0	0.0%	
T3-STURGEON CREEK -PERIMETER	0.15	0.02	2.12	0.36	47	0	0.0%	
T4-STURGEON CREEK -PORTAGE	0.28	0.02	2.90	0.50	47	0	0.0%	
T5-OMAND'S CREEK -PORTAGE	N/A							
T6-LA SALLE RIVER -HWY #75	0.13	0.02	1.52	0.26	47	0	0.0%	
T7-BUNNS CREEK -HENDERSON	N/A							

N/A = Classification not applicable

TABLE A105 : Trend analysis results for the nitrate /nitrite data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	**R2**	**P**		**TREND**	**N**
T1-SEINE RIVER - HWY #59	0.00	0.713	N/S	INCREASING	57
T2-SEINE RIVER - PROVENCHER	0.00	0.729	N/S	INCREASING	57
T3-STURGEON CREEK - PERIMETER	0.02	0.278	N/S	INCREASING	57
T4-STURGEON CREEK - PORTAGE	0.00	0.925	N/S	INCREASING	57
T5-OMAND'S CREEK - PORTAGE	0.03	0.241	N/S	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.00	0.75	N/S	DECREASING	57
T7-BUNNS CREEK - HENDERSON	0.03	0.216	N/S	DECREASING	57

* indicates significance level at P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend (P>0.05)
N refers to the sample size

FIGURE A203: Phosphorus concentrations in the Seine River at site T1 at Highway #59.

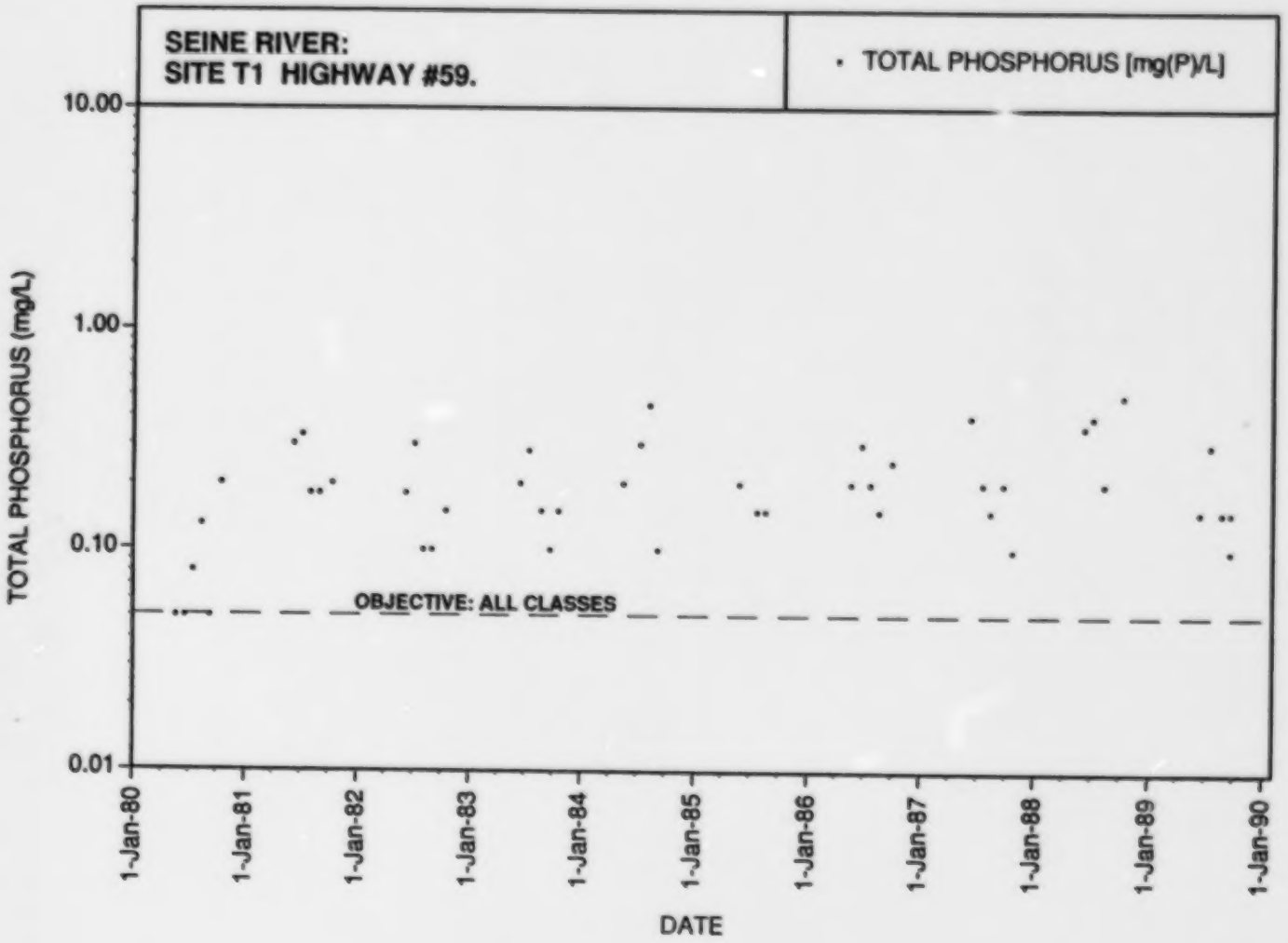


FIGURE A204: Phosphorus concentrations in the Seine River, at site T2 at the Provencher Street Bridge.

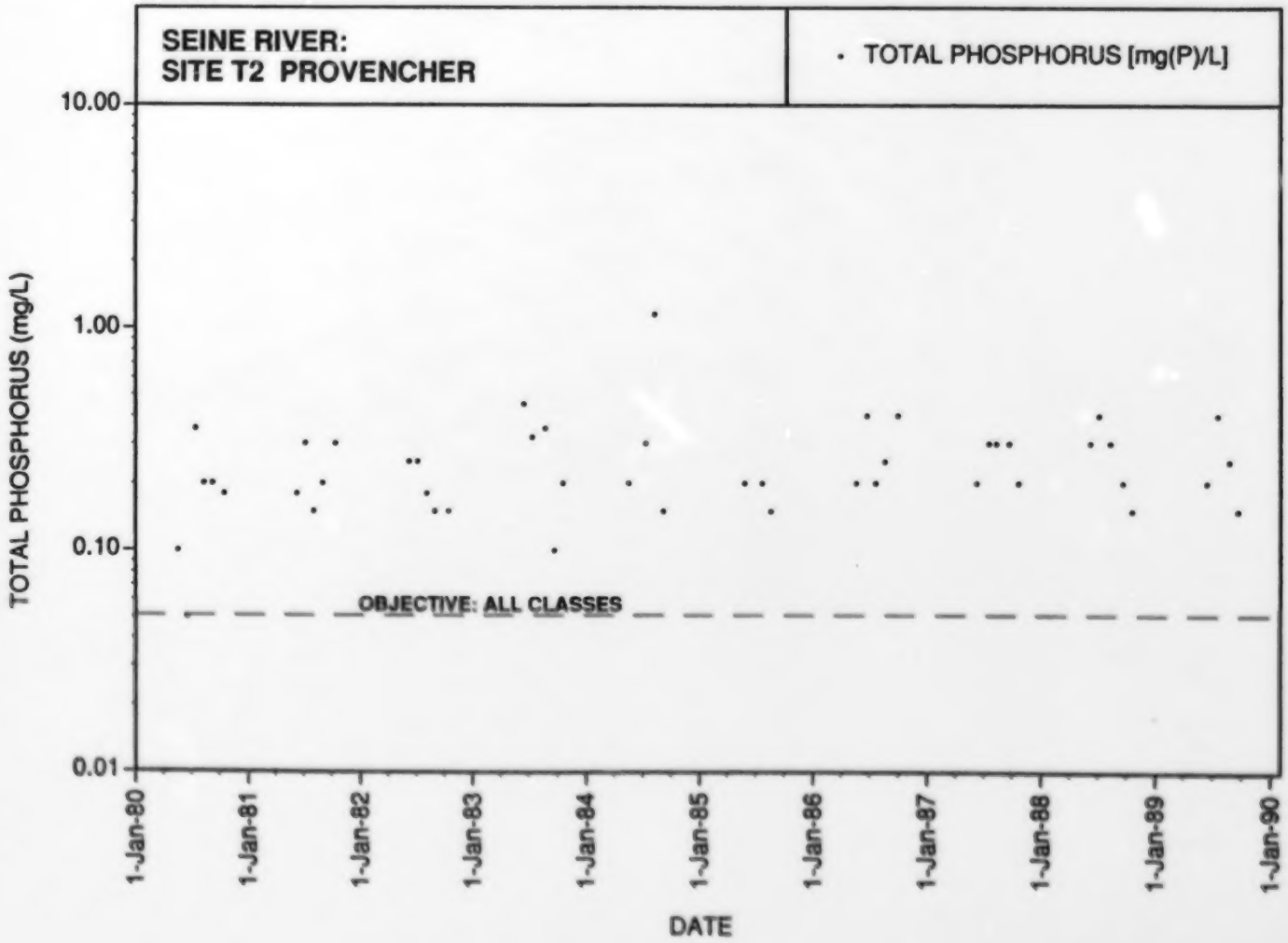


FIGURE A205: Phosphorus concentrations in Sturgeon Creek, at site T3 at the perimeter.

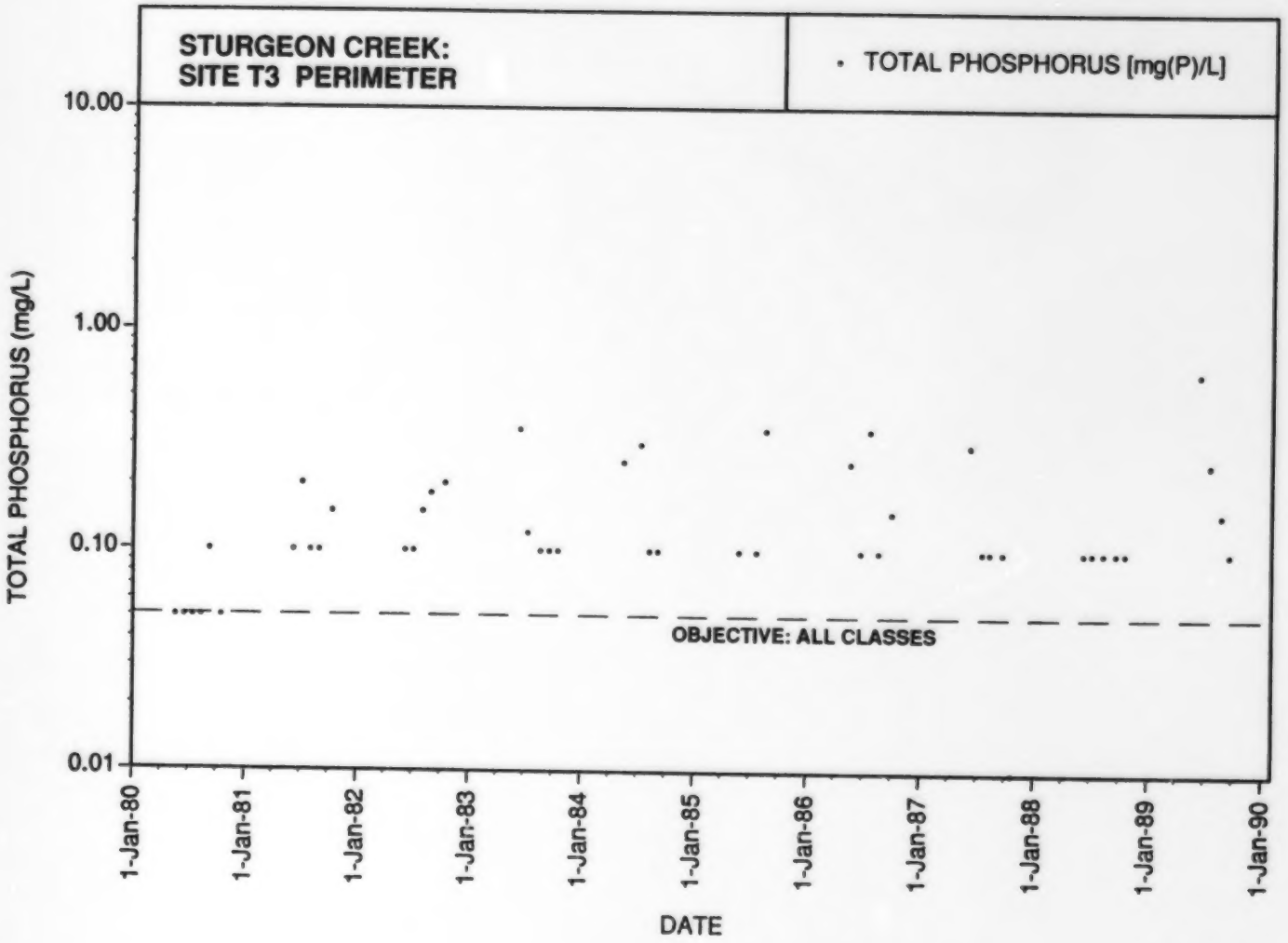


FIGURE A206: Phosphorus concentrations in Sturgeon Creek, at site T4 at Portage Avenue.

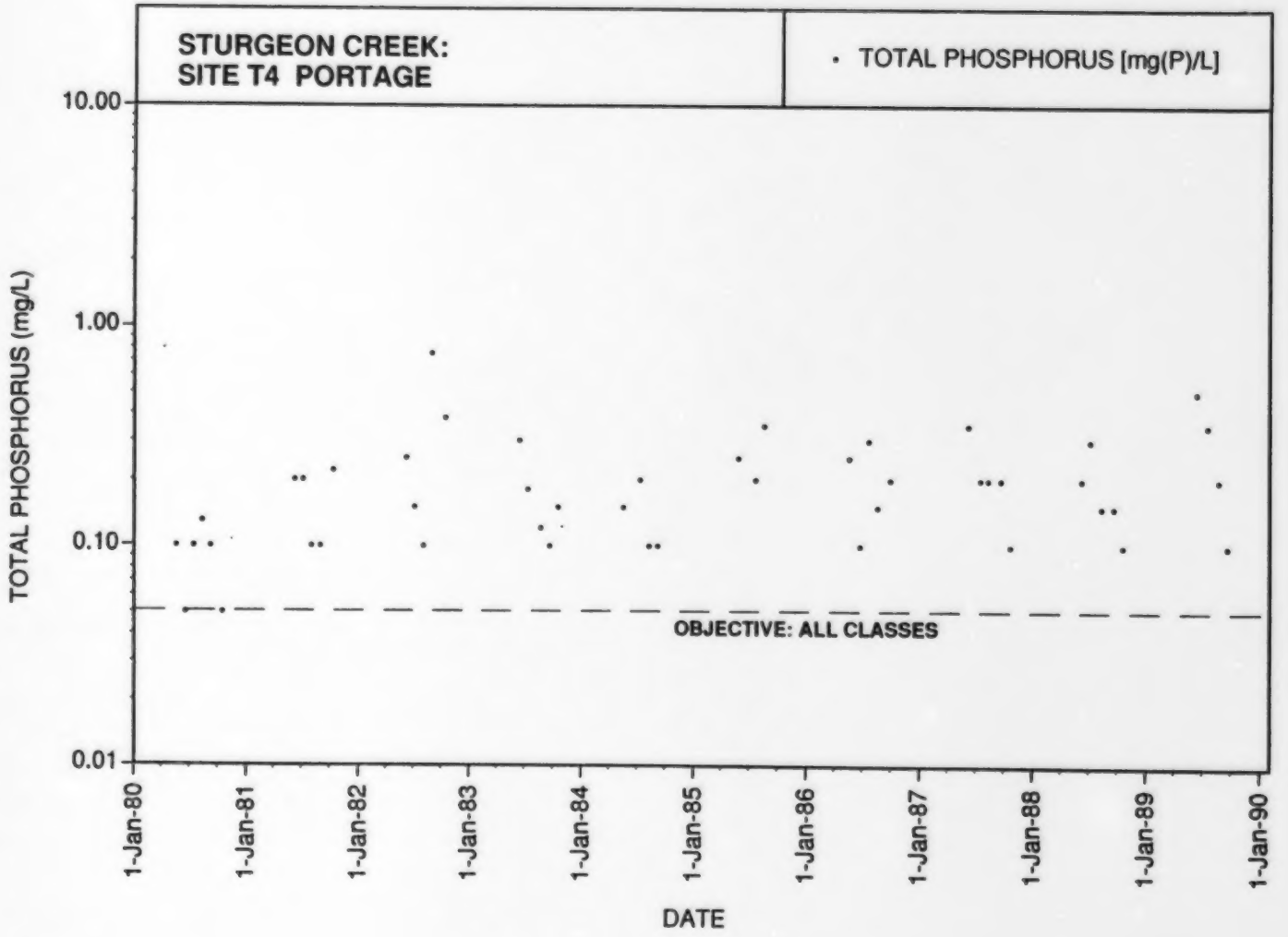


FIGURE A207: Phosphorus concentrations in Omand's Creek, at site T5 at Portage Avenue.

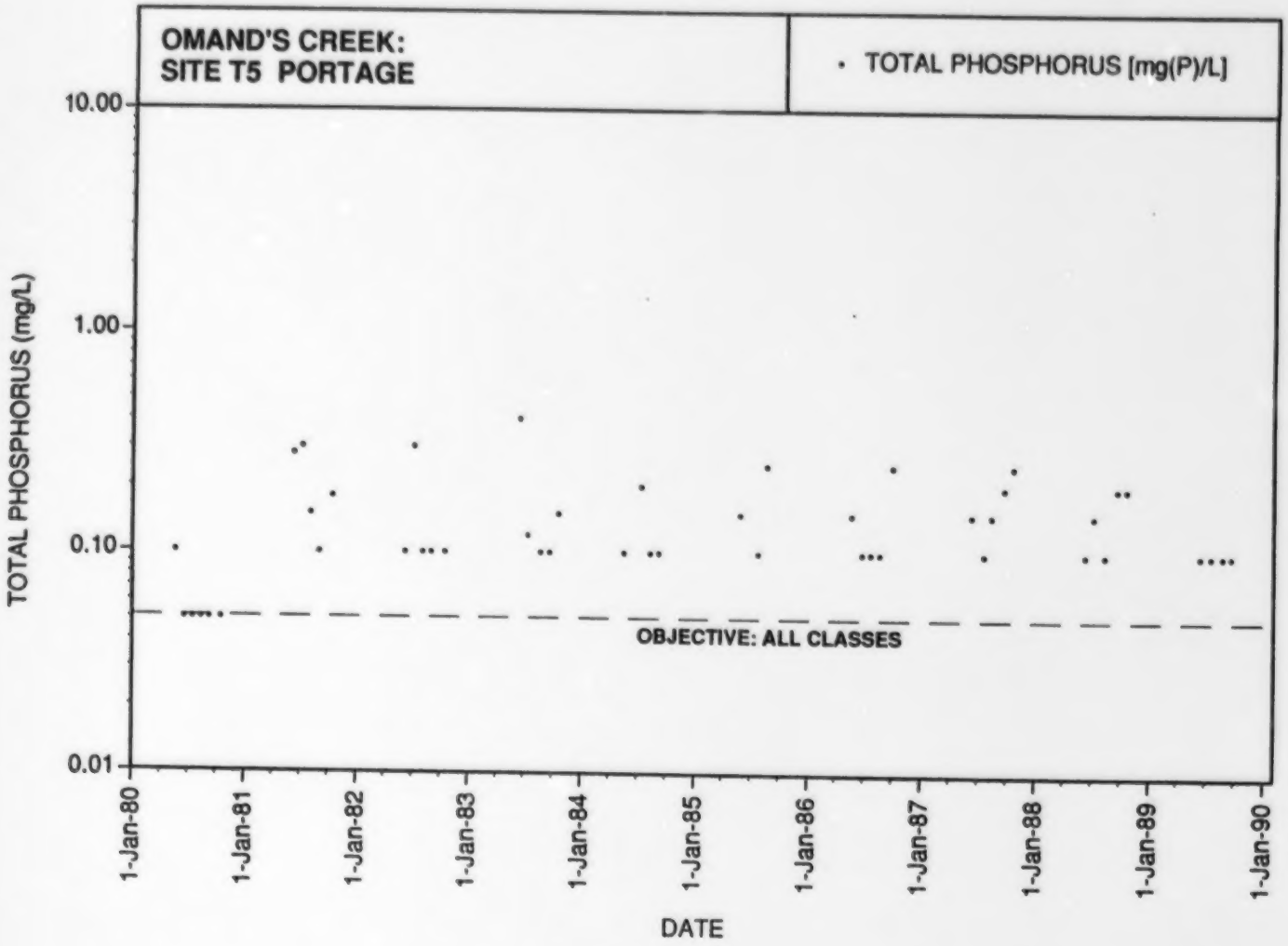


FIGURE A208: Phosphorus concentrations in the La Salle River, at site T6 at Highway #75.

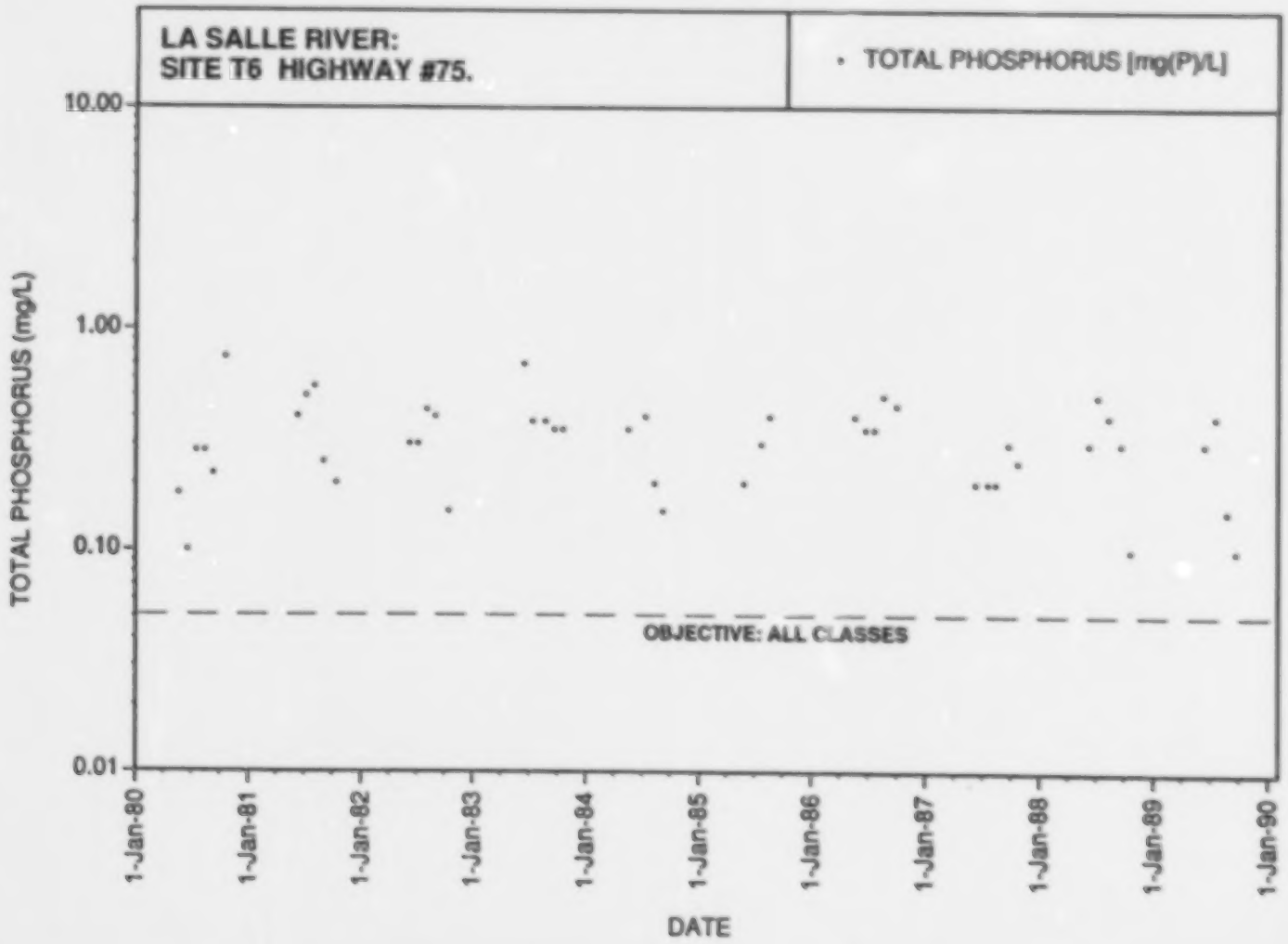


FIGURE A209: Phosphorus concentrations in Bunn's Creek, at site T7 at Henderson Highway.

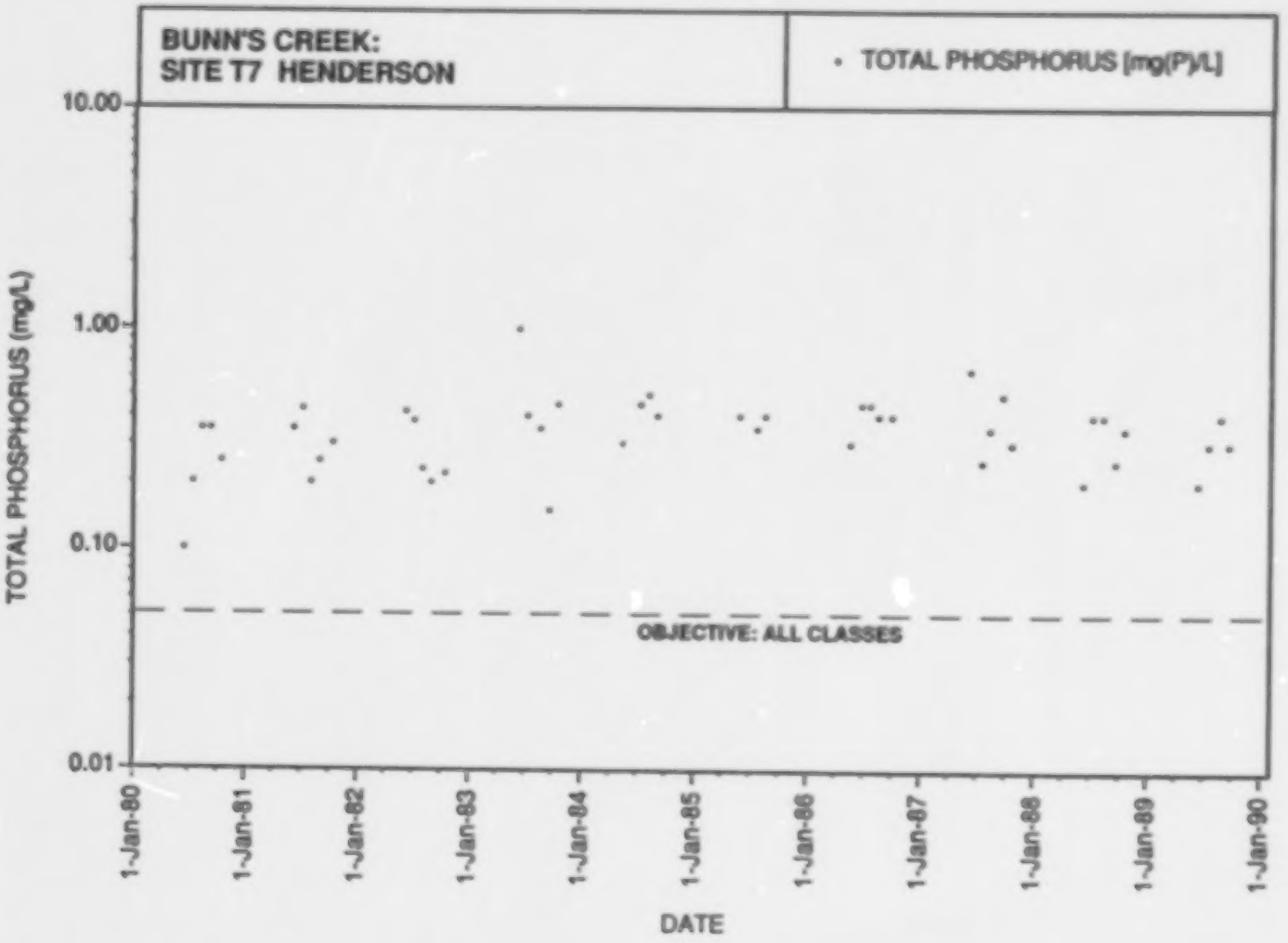


TABLE A106: Summary statistics and exceedences of the phosphorus objective in the tributaries.

PARAMETER: PHOSPHORUS
MSWQO CLASSIFICATION: ALL CLASSES
OBJECTIVE: 0.05 (mg/L)

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	0.20	0.05	0.50	0.10	47	44	93.6%	0.21
T2-SEINE RIVER -PROVENCHER	0.26	0.05	1.15	0.16	47	46	97.9%	0.26
T3-STURGEON CREEK -PERIMETER	0.15	0.01	0.65	0.11	47	41	87.2%	0.16
T4-STURGEON CREEK -PORTAGE	0.20	0.05	0.75	0.13	47	45	95.7%	0.20
T5-OMAND'S CREEK -PORTAGE	0.14	0.05	0.40	0.08	47	42	89.4%	0.15
T6-LA SALLE RIVER -HWY #75	0.32	0.10	0.75	0.14	47	47	100.0%	0.32
T7-BUNNS CREEK -HENDERSON	0.35	0.10	1.00	0.14	47	47	100.0%	0.35

TABLE A107: Trend analysis results for phosphorus data in the tributaries.

MAY-OCTOBER:1976-1989 DATA					
SAMPLING LOCATION	**R2**	**P**		**TREND**	**N**
T1-SEINE RIVER - HWY #59	0.13	0.005	**	INCREASING	57
T2-SEINE RIVER - PROVENCHER	0.00	0.729	N/S	INCREASING	57
T3-STURGEON CREEK - PERIMETER	0.09	0.020	*	INCREASING	57
T4-STURGEON CREEK - PORTAGE	0.08	0.029	*	INCREASING	57
T5-OMAND'S CREEK - PORTAGE	0.08	0.038	*	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.01	0.462	N/S	INCREASING	57
T7-BUNNS CREEK - HENDERSON	0.05	0.087	N/S	DECREASING	57

* indicates significance level at P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend (P>0.05)
N refers to the sample size

FIGURE A210: pH levels in the Seine River, at site T1 at Highway #59.

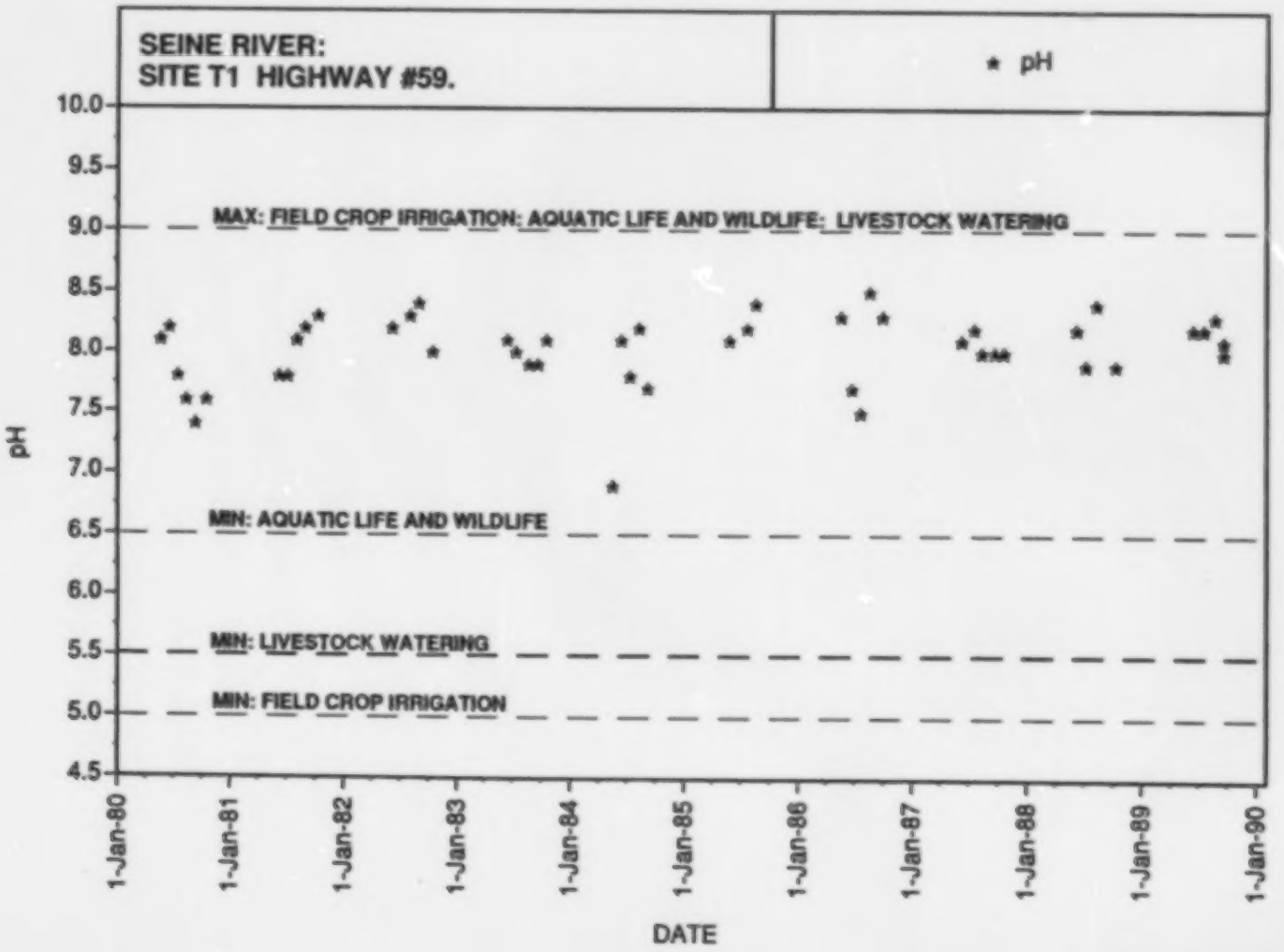


FIGURE A211: pH levels in the Seine River, at site T2 at the Provencher Street Bridge.

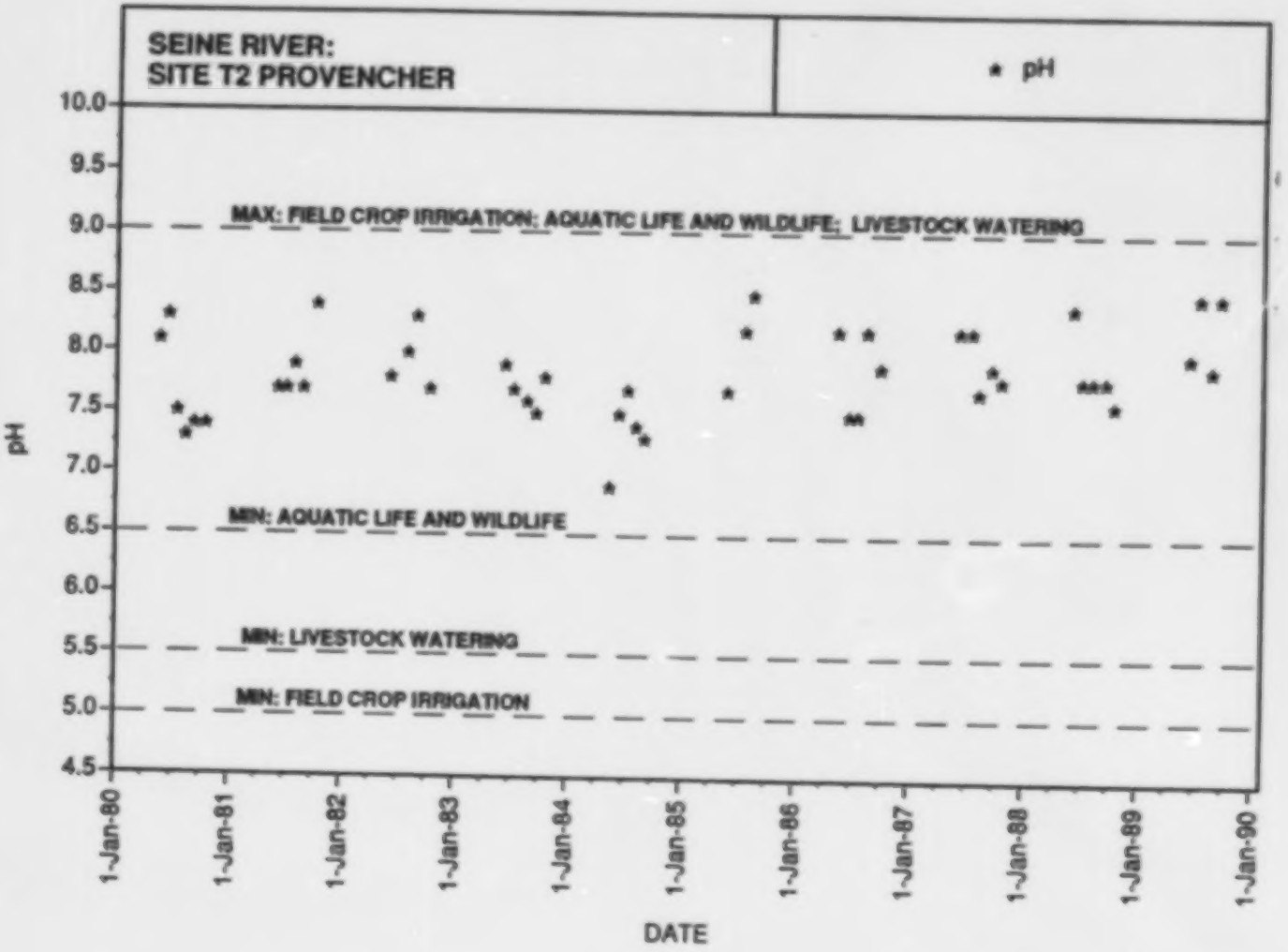


FIGURE A212: pH levels in Sturgeon Creek, at site T3 at the perimeter.

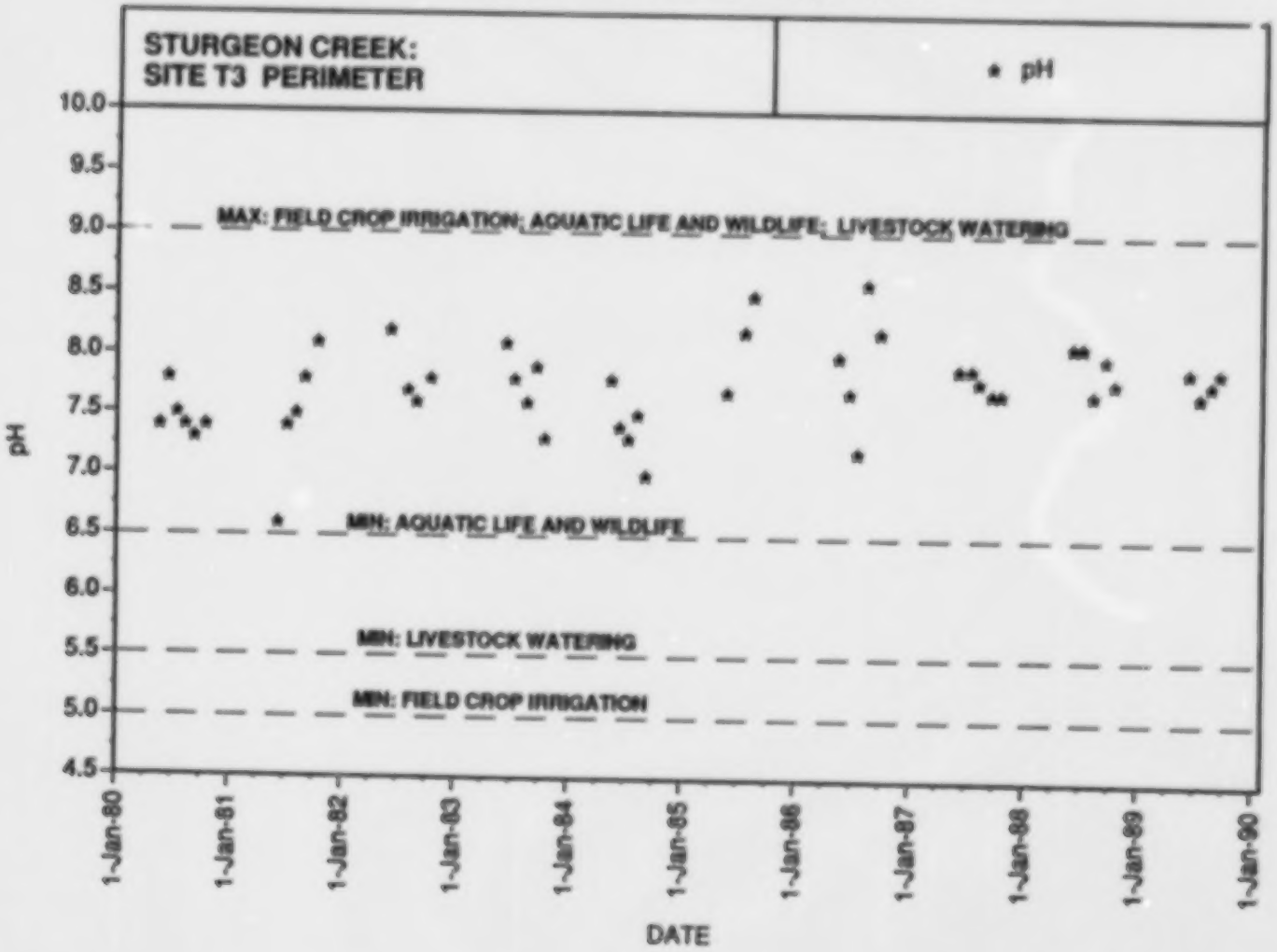


FIGURE A213: pH levels in Sturgeon Creek, at site T4 at Portage Avenue.

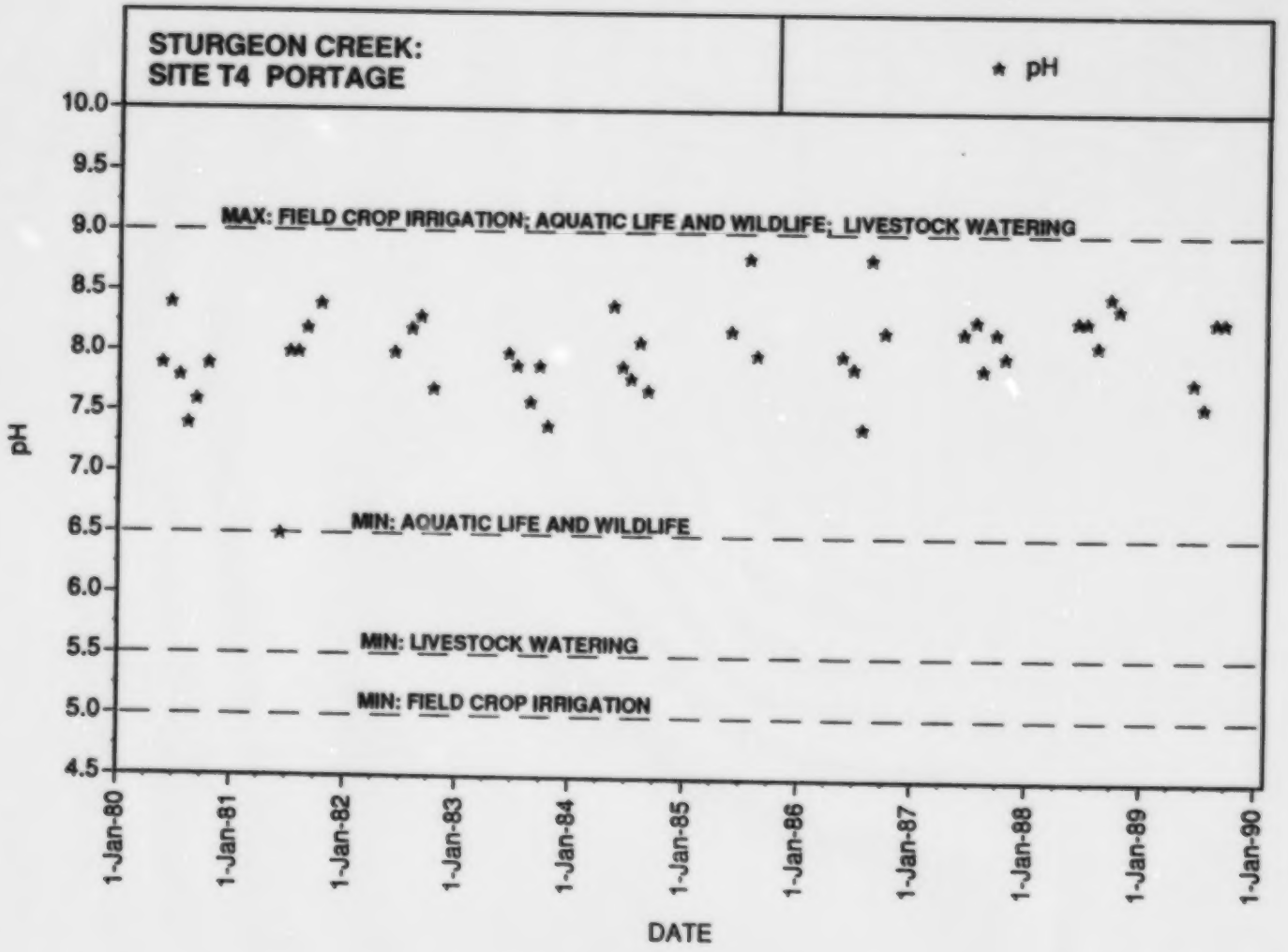


FIGURE A214: pH levels in Omand's Creek, at site T5 at Portage Avenue.

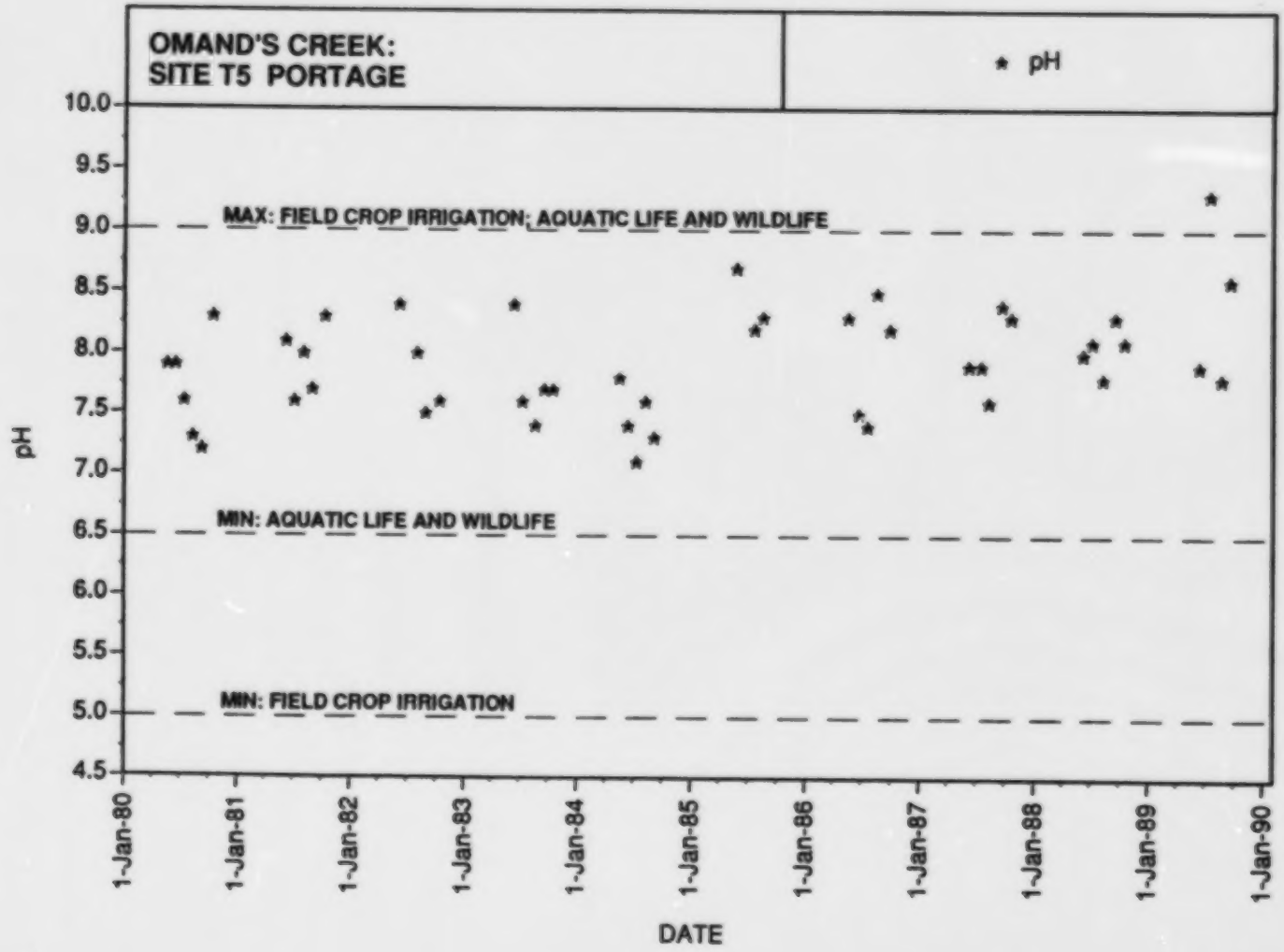


FIGURE A215: pH levels in the La Salle River, at site T6 at Highway #75.

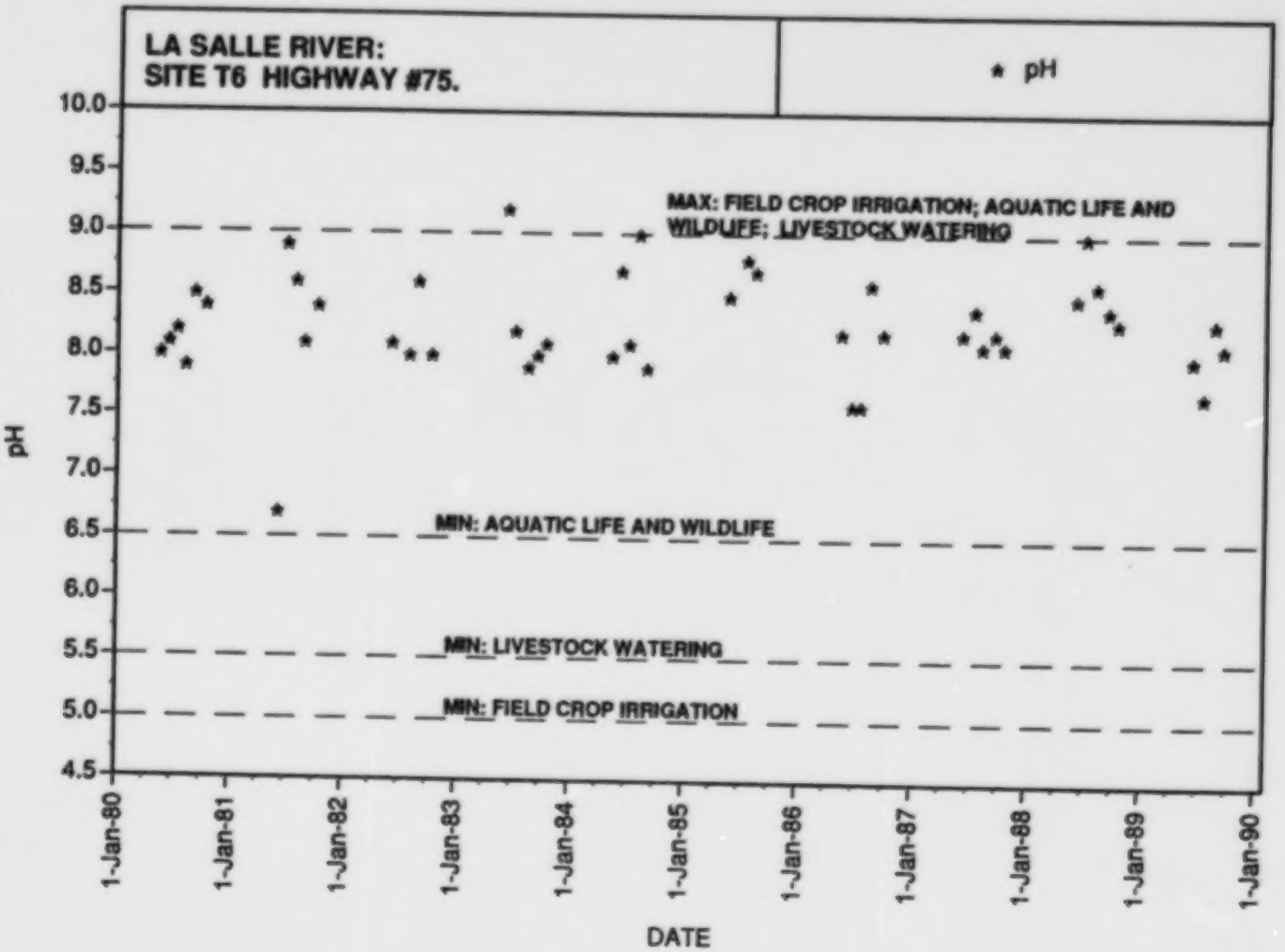


FIGURE A216: pH levels in Bunn's Creek, at site T7 at Henderson Highway.

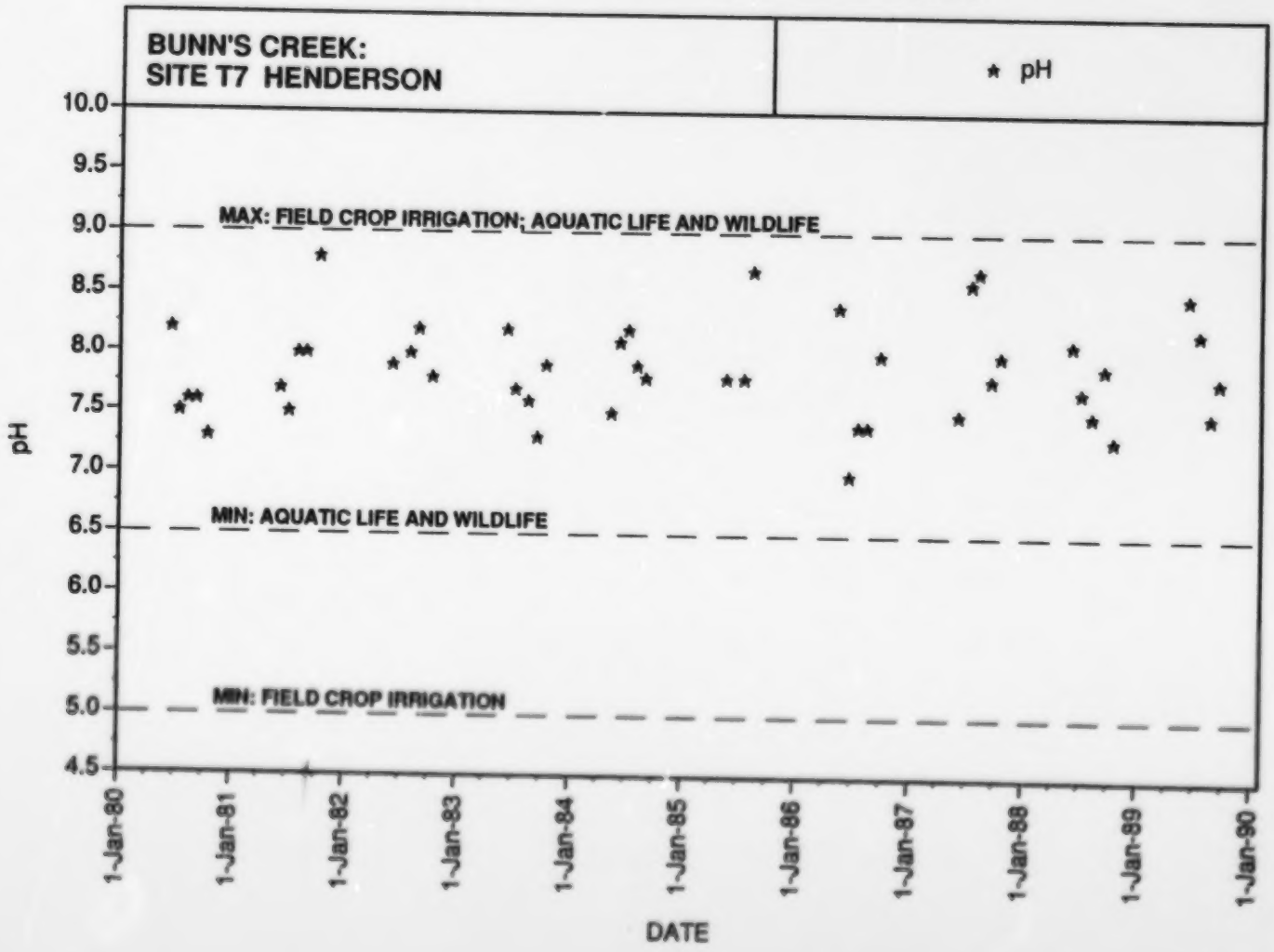


TABLE A108: Summary statistics and exceedences of the pH objective, for field crop irrigation in the tributaries.

PARAMETER: pH
MSWQO CLASSIFICATION: FIELD CROP IRRIGATION
OBJECTIVE: MIN=5.0, MAX=9.0 (pH Units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	8.0	6.9	8.5	0.3	47	0	0.0%	
T2-SEINE RIVER -PROVENCHER	7.8	6.9	8.5	0.4	47	0	0.0%	
T3-STURGEON CREEK -PERIMETER	7.7	6.6	8.6	0.4	47	0	0.0%	
T4-STURGEON CREEK -PORTAGE	8.0	6.5	8.8	0.4	47	0	0.0%	
T5-OMAND'S CREEK -PORTAGE	7.9	7.1	9.3	0.4	47	1	2.1%	
T6-LA SALLE RIVER -HWY #75	8.2	6.7	9.2	0.4	47	1	2.1%	
T7-BUNNS CREEK -HENDERSON	7.9	7.0	8.8	0.4	47	0	0.0%	

TABLE A109: Summary statistics and exceedences of the pH objective, for aquatic life and wildlife in the tributaries.

PARAMETER: pH
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: MIN=6.5, MAX=9.0 (pH Units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	8.0	6.9	8.5	0.3	47	0	0.0%	
T2-SEINE RIVER -PROVENCHER	7.8	6.9	8.5	0.4	47	0	0.0%	
T3-STURGEON CREEK -PERIMETER	7.7	6.6	8.6	0.4	47	0	0.0%	
T4-STURGEON CREEK -PORTAGE	8.0	6.5	8.8	0.4	47	0	0.0%	
T5-OMAND'S CREEK -PORTAGE	7.9	7.1	9.3	0.4	47	1	2.1%	
T6-LA SALLE RIVER -HWY #75	8.2	6.7	9.2	0.4	47	1	2.1%	
T7-BUNNS CREEK -HENDERSON	7.9	7.0	8.8	0.4	47	0	0.0%	

TABLE A110: Summary statistics and exceedences of the pH objective, for livestock watering in the tributaries.

PARAMETER: pH
MSWQO CLASSIFICATION: LIVESTOCK WATERING
OBJECTIVE: MIN=5.5, MAX=9.0 (pH Units) [EXCEEDENCE REFERS TO LEVELS OUTSIDE OF THE OBJECTIVE]

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	8.0	6.9	8.5	0.3	47	0	0.0%	
T2-SEINE RIVER -PROVENCHER	7.8	6.9	8.5	0.4	47	0	0.0%	
T3-STURGEON CREEK -PERIMETER	7.7	6.6	8.6	0.4	47	0	0.0%	
T4-STURGEON CREEK -PORTAGE	8.0	6.5	8.8	0.4	47	0	0.0%	
T5-OMAND'S CREEK -PORTAGE	N/A							
T6-LA SALLE RIVER -HWY #75	8.2	6.7	9.2	0.4	47	1	2.1%	
T7-BUNNS CREEK -HENDERSON	N/A							

N/A = Classification not applicable

TABLE A111: Trend analysis results for pH data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	R2	P		TREND	N
T1-SEINE RIVER - HWY #59	0.00	0.714	N/S	INCREASING	57
T2-SEINE RIVER - PROVENCHER	0.00	0.897	N/S	INCREASING	57
T3-STURGEON CREEK - PERIMETER	0.05	0.101	N/S	INCREASING	57
T4-STURGEON CREEK - PORTAGE	0.01	0.384	N/S	INCREASING	57
T5-OMAND'S CREEK - PORTAGE	0.06	0.070	N/S	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.01	0.558	N/S	INCREASING	57
T7-BUNNS CREEK - HENDERSON	0.00	0.396	N/S	DECREASING	57

* indicates significance level at $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend ($P>0.05$)
N refers to the sample size

FIGURE A217: Percent saturation of oxygen in the Seine River, at site T1 at Highway #59.

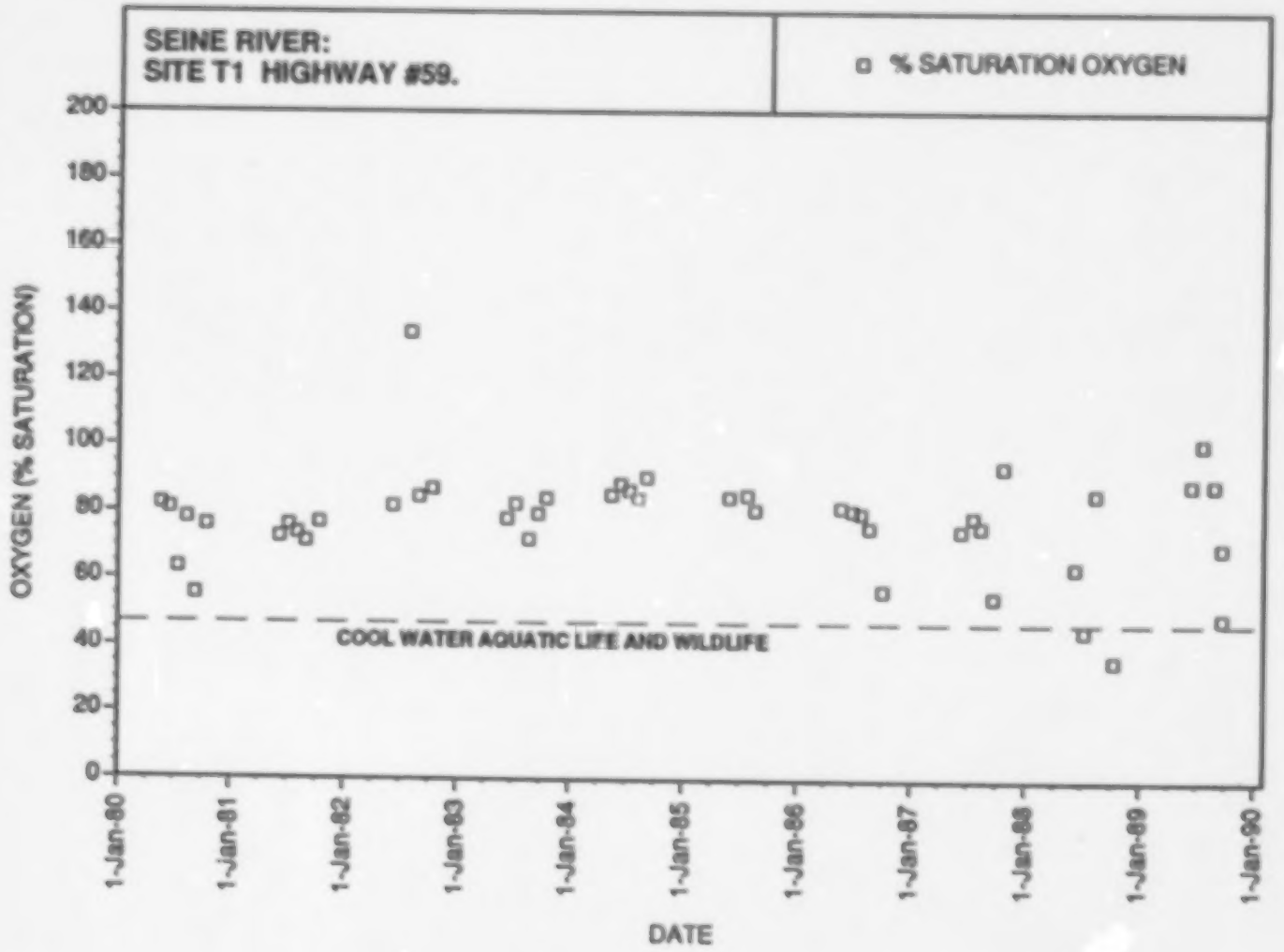


FIGURE A218: Percent saturation of oxygen in the Seine River, at site T2 at the Provencher Street Bridge.

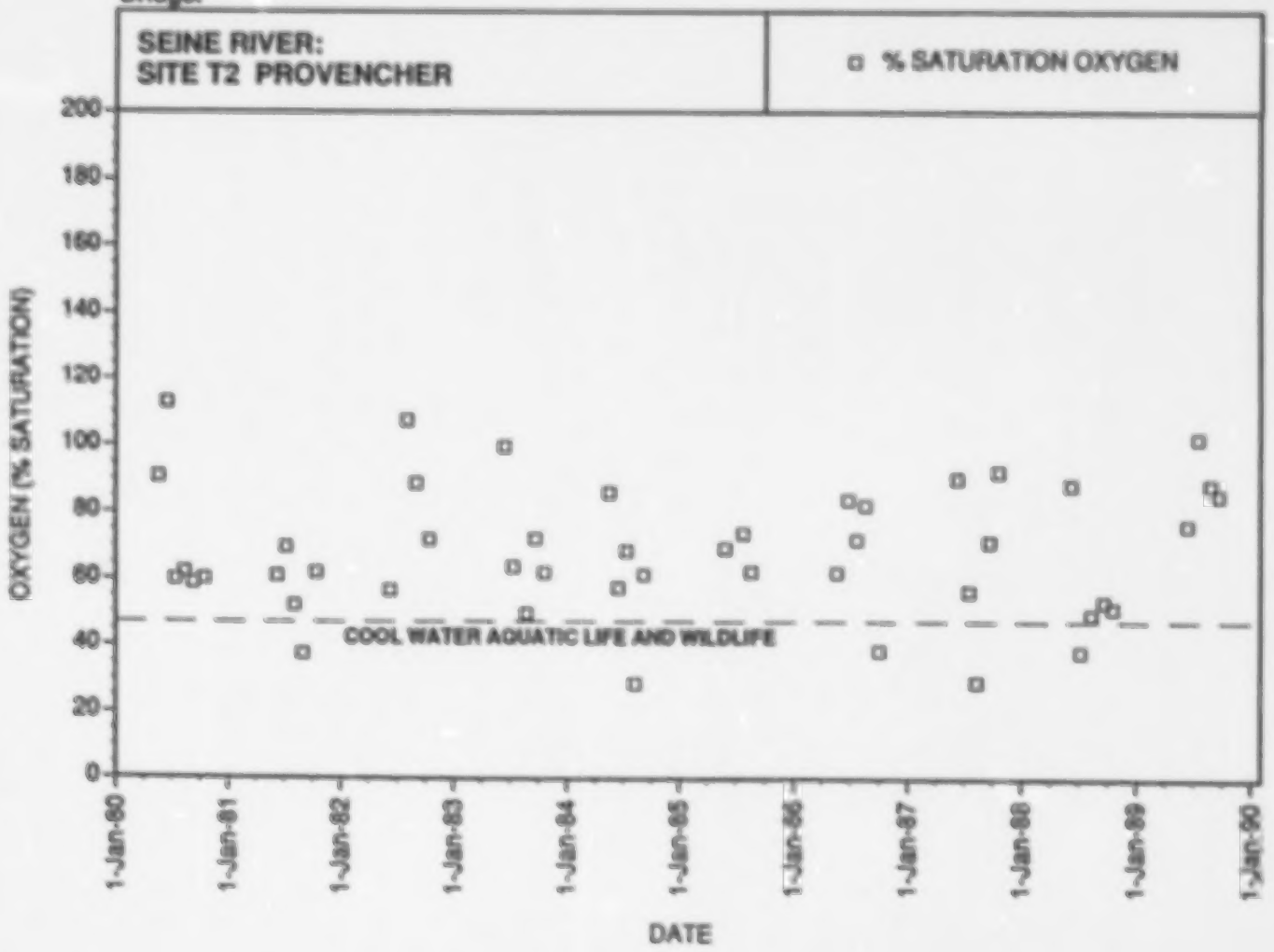


FIGURE A219: Percent saturation of oxygen in Sturgeon Creek, at site T3 at the perimeter.

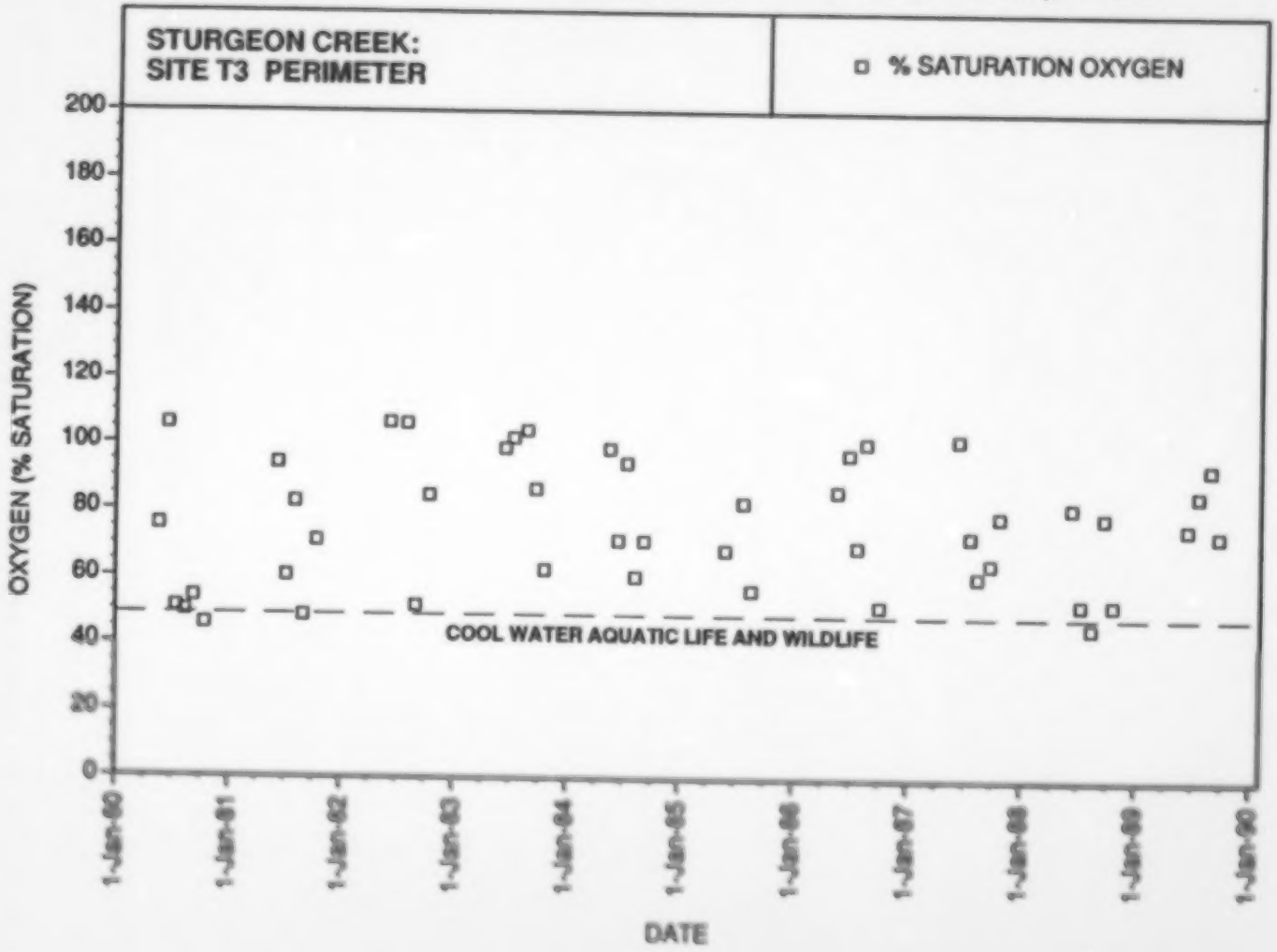


FIGURE A220: Percent saturation of oxygen in Sturgeon Creek, at site T4 at Portage Avenue.

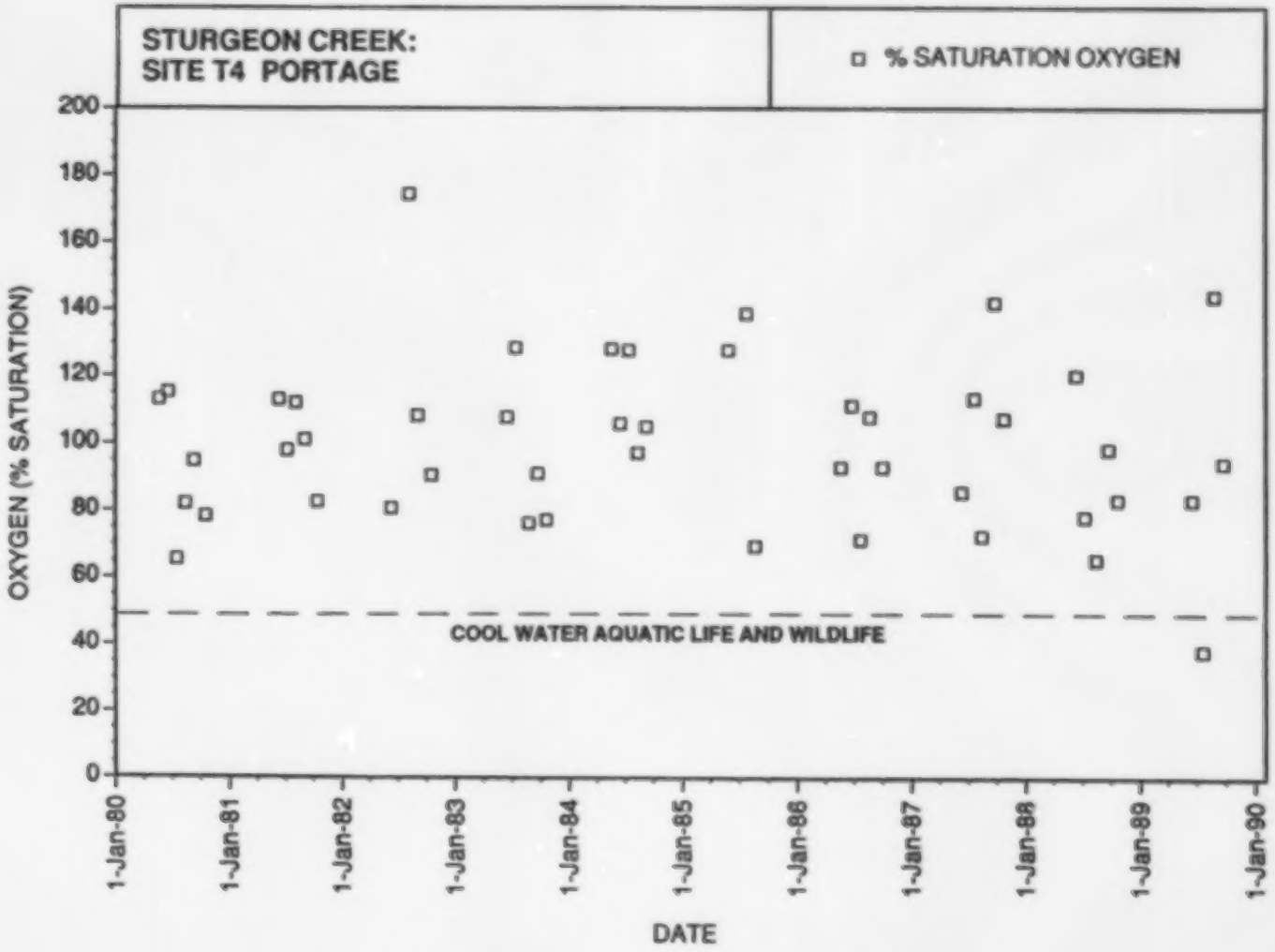


FIGURE A221: Percent saturation levels in Omand's Creek, at site T5 at Portage Avenue.

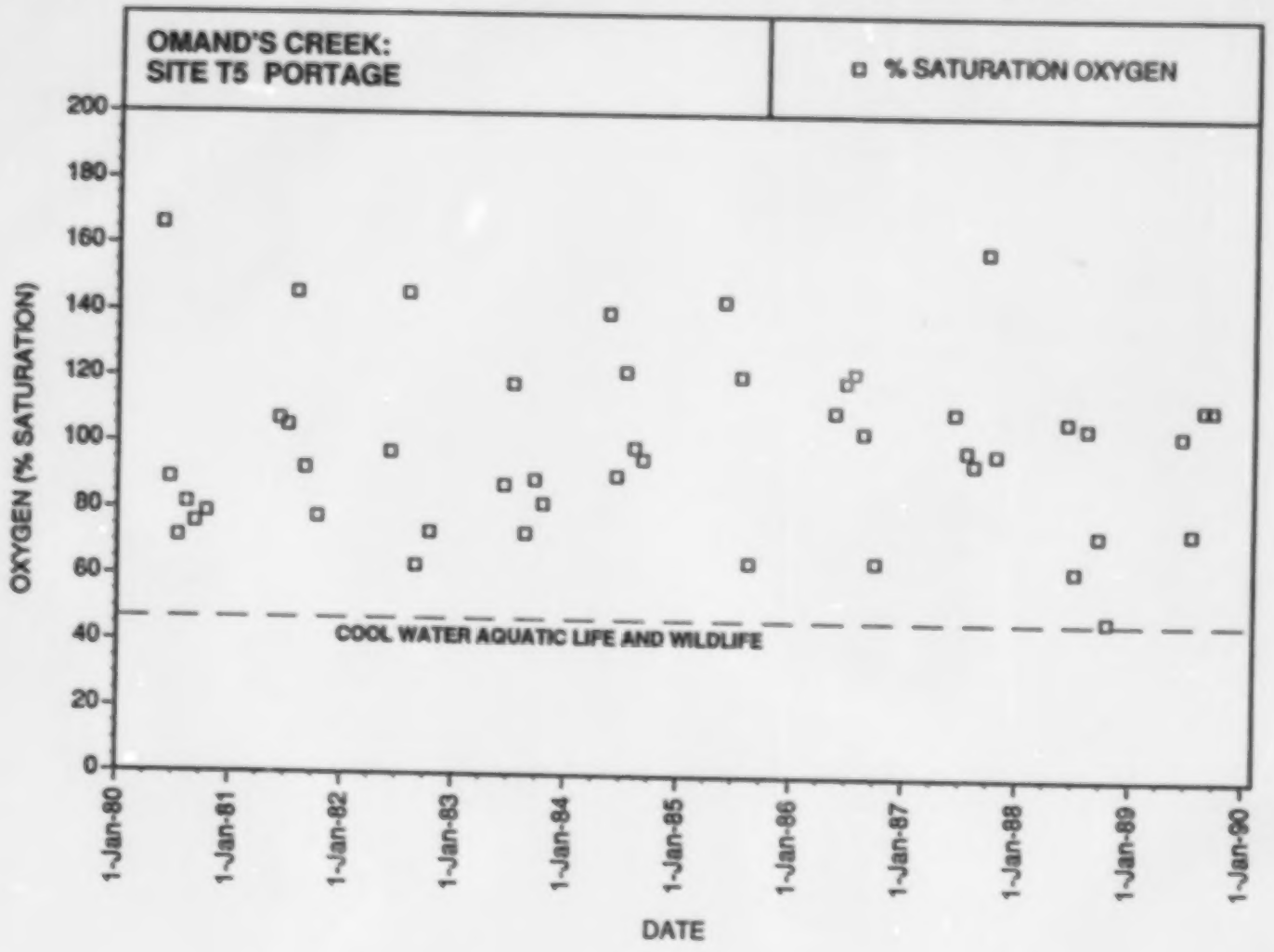


FIGURE A222: Percent saturation of oxygen in the La Salle River, at site T6 at Highway #75.

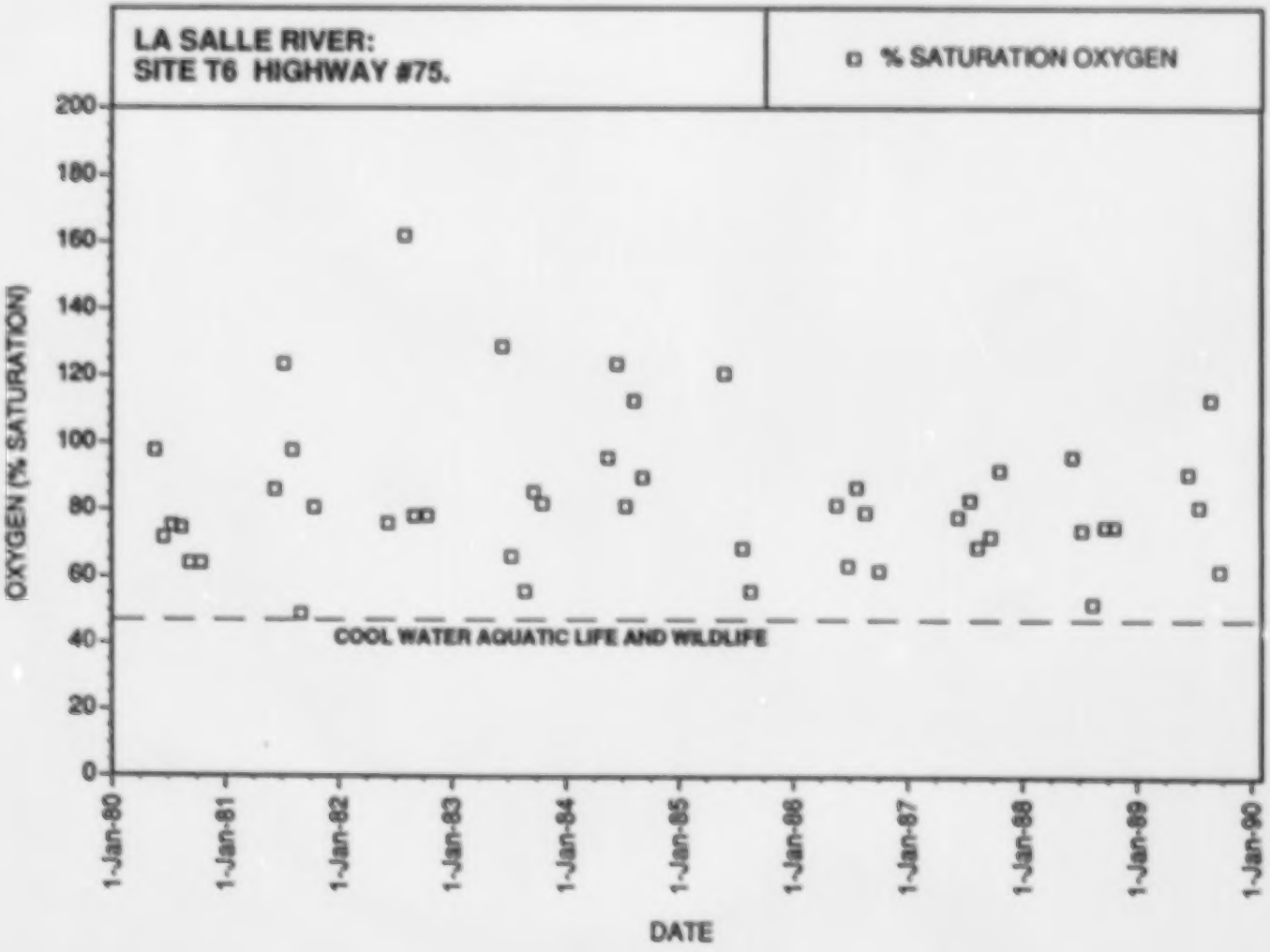


FIGURE A223: Percent saturation of oxygen in Bunn's Creek, at site T7 at Henderson Highway.

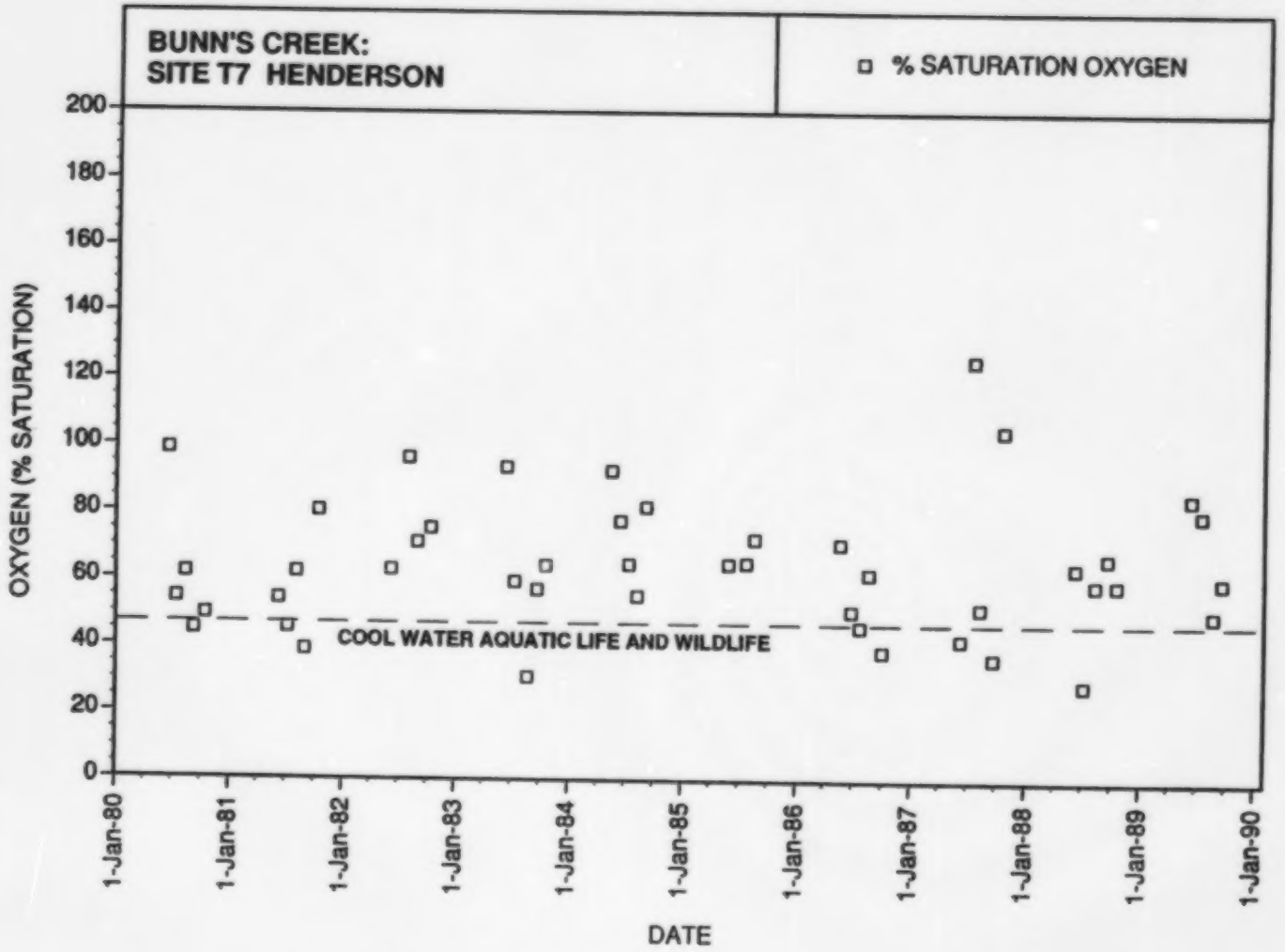


TABLE A112: Summary statistics and exceedences of the oxygen objective, for aquatic life and wildlife in the tributaries.

PARAMETER: % SATURATION OXYGEN
MSWQO CLASSIFICATION: COOL WATER AQUATIC LIFE AND WILDLIFE
OBJECTIVE: 47 % [EXCEEDENCE REFERS TO LEVELS BELOW THE OBJECTIVE]

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	77.9	36.0	133.9	15.3	47	2	4.3%	40.5
T2-SEINE RIVER -PROVENCHER	68.3	28.4	112.9	19.7	47	5	10.6%	34.2
T3-STURGEON CREEK -PERIMETER	76.1	45.7	106.7	19.1	47	2	4.3%	45.8
T4-STURGEON CREEK -PORTAGE	99.6	38.0	174.2	24.9	47	1	2.1%	38.0
T5-OMAND'S CREEK -PORTAGE	99.7	48.0	166.2	26.6	47	0	0.0%	
T6-LA SALLE RIVER -HWY #75	83.6	48.9	162.2	22.3	47	0	0.0%	
T7-BUNNS CREEK -HENDERSON	64.9	29.0	126.0	20.2	47	9	19.1%	39.2

TABLE A113: Trend analysis results for dissolved oxygen data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	**R2**	**P**		**TREND**	**N**
T1-SEINE RIVER - HWY #59	0.07	0.050	*	DECREASING	57
T2-SEINE RIVER - PROVENCHER	0.06	0.070	N/S	DECREASING	57
T3-STURGEON CREEK - PERIMETER	0.08	0.037	*	DECREASING	57
T4-STURGEON CREEK - PORTAGE	0.10	0.015	*	DECREASING	57
T5-OMAND'S CREEK - PORTAGE	0.00	0.632	N/S	DECREASING	57
T6-LA SALLE RIVER - HWY #75	0.03	0.211	N/S	DECREASING	57
T7-BUNNS CREEK - HENDERSON	0.00	0.800	N/S	DECREASING	57

* indicates significance level at $P<0.05$
** indicates significance level of $P<0.01$
N/S indicates no significant trend ($P>0.05$)
N refers to the sample size

FIGURE A224: Total organic carbon concentrations in the Seine River, at site T1 at Highway #59.

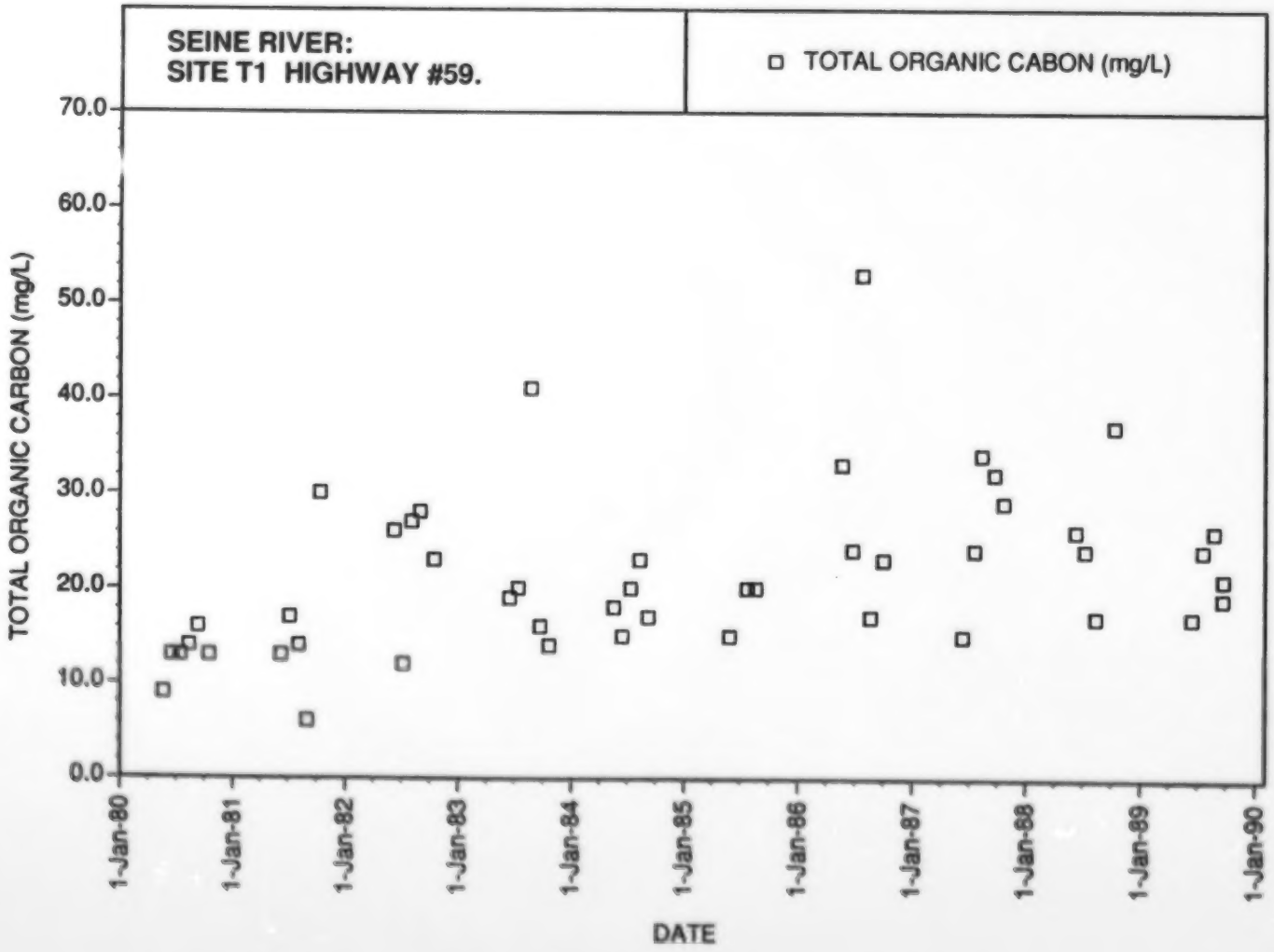


FIGURE A225: Total organic carbon concentrations in the Seine River, at site T2 at the Provencher Street Bridge.

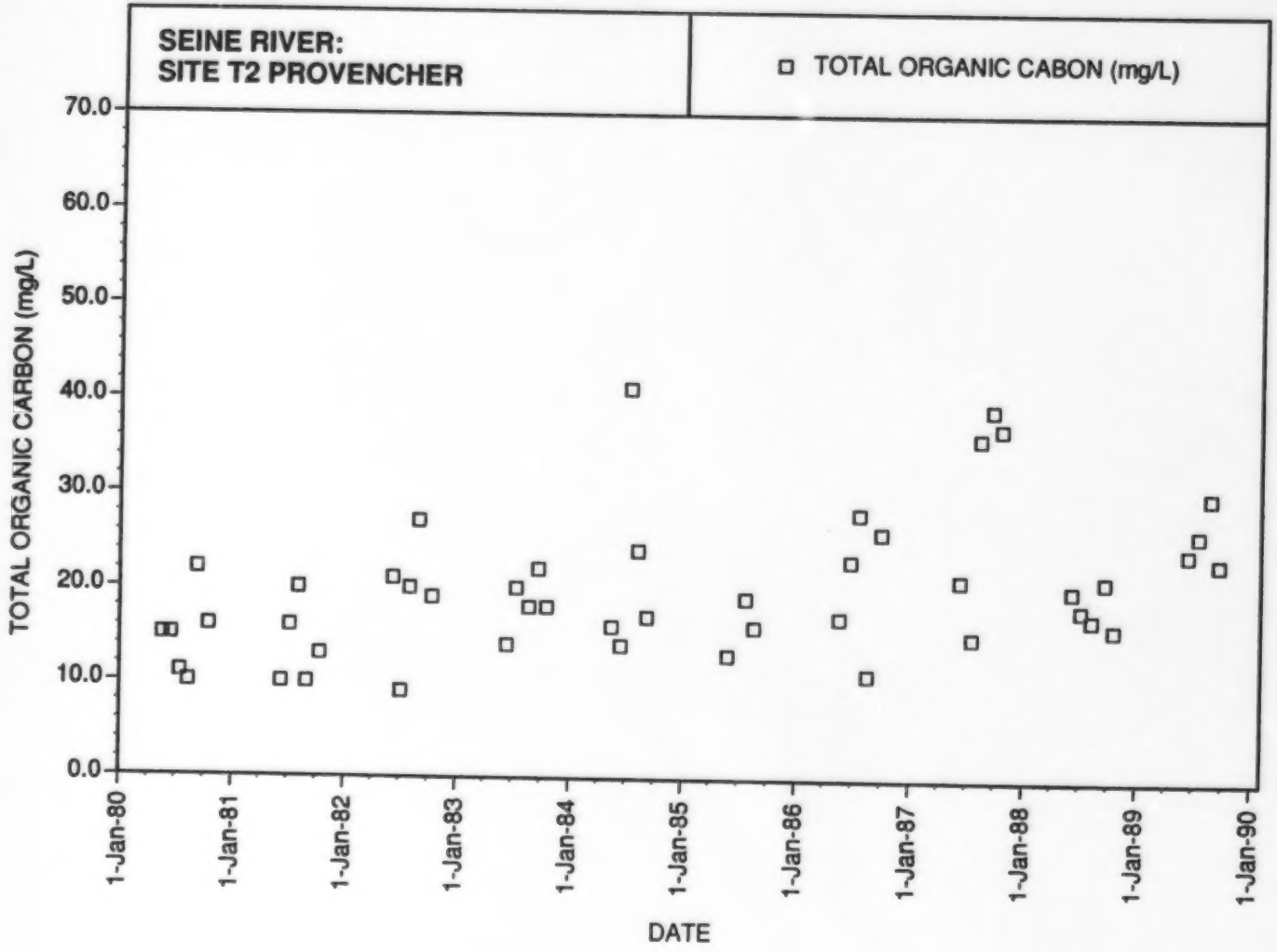


FIGURE A226: Total organic carbon concentrations in Sturgeon Creek, at site T3 at the perimeter.

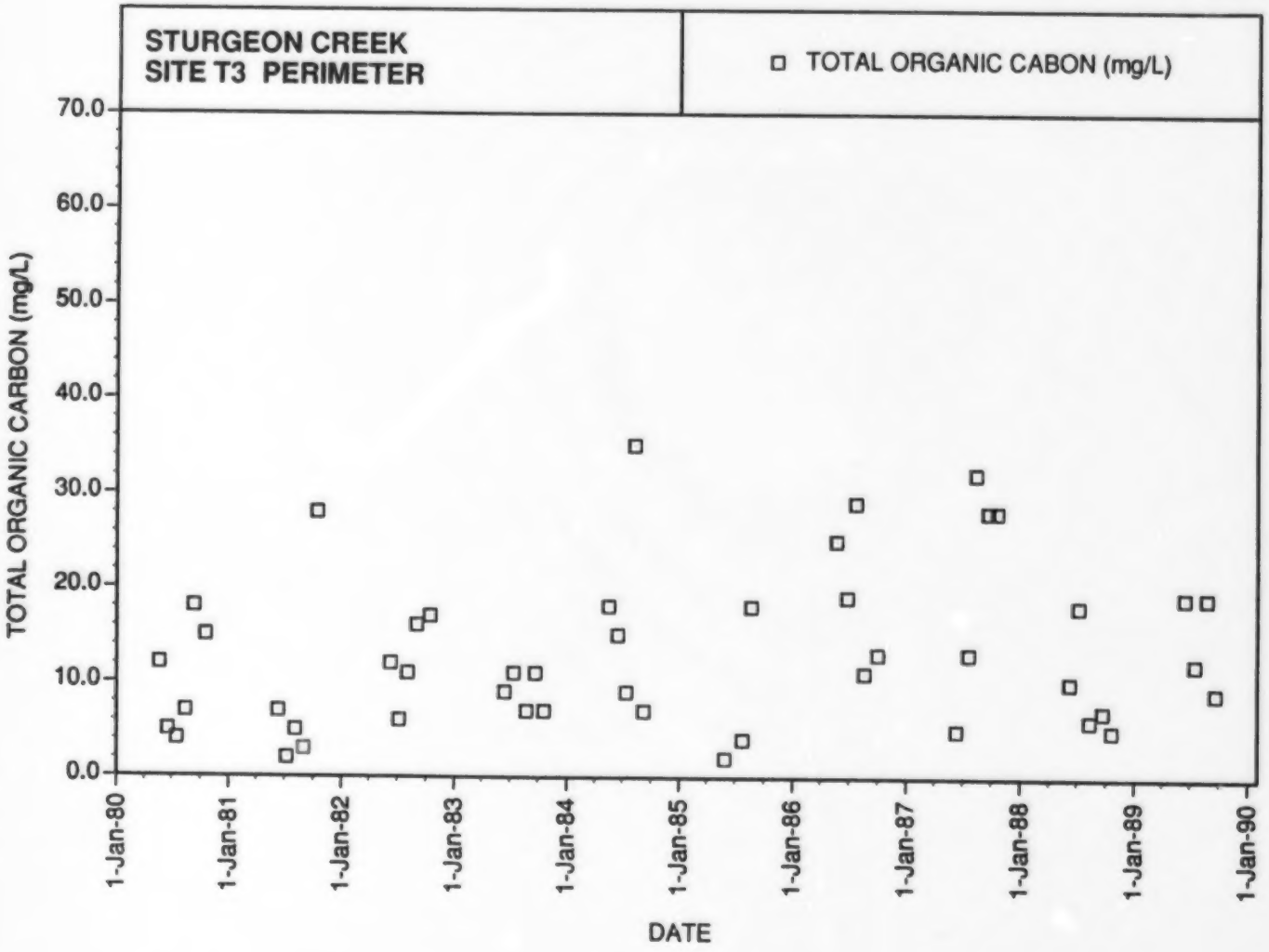


FIGURE A227: Total organic carbon concentrations in Sturgeon Creek, at site T4 at Portage Avenue.

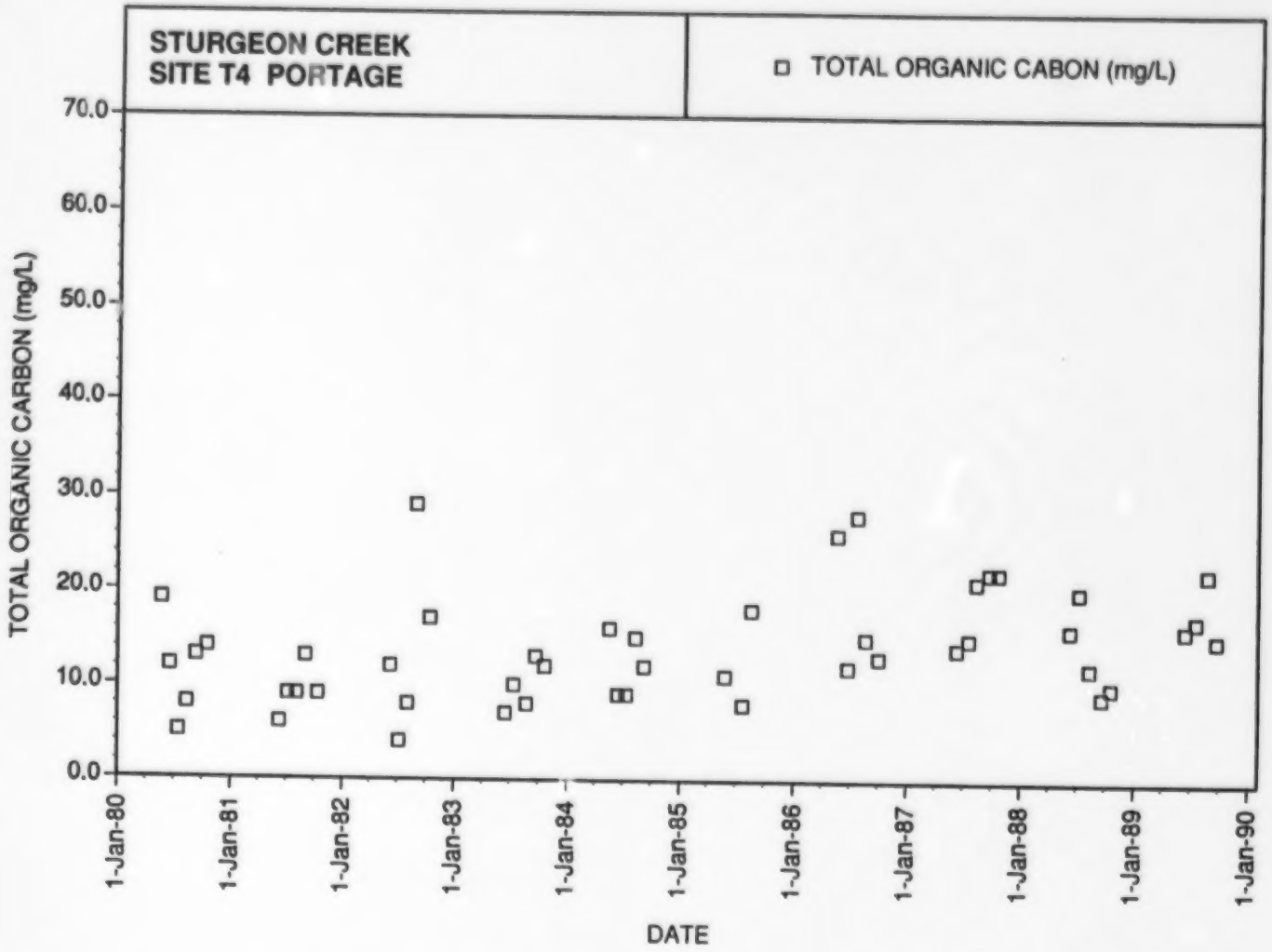


FIGURE A228: Total organic carbon concentrations in Omand's Creek, at site T5 at Portage Avenue.

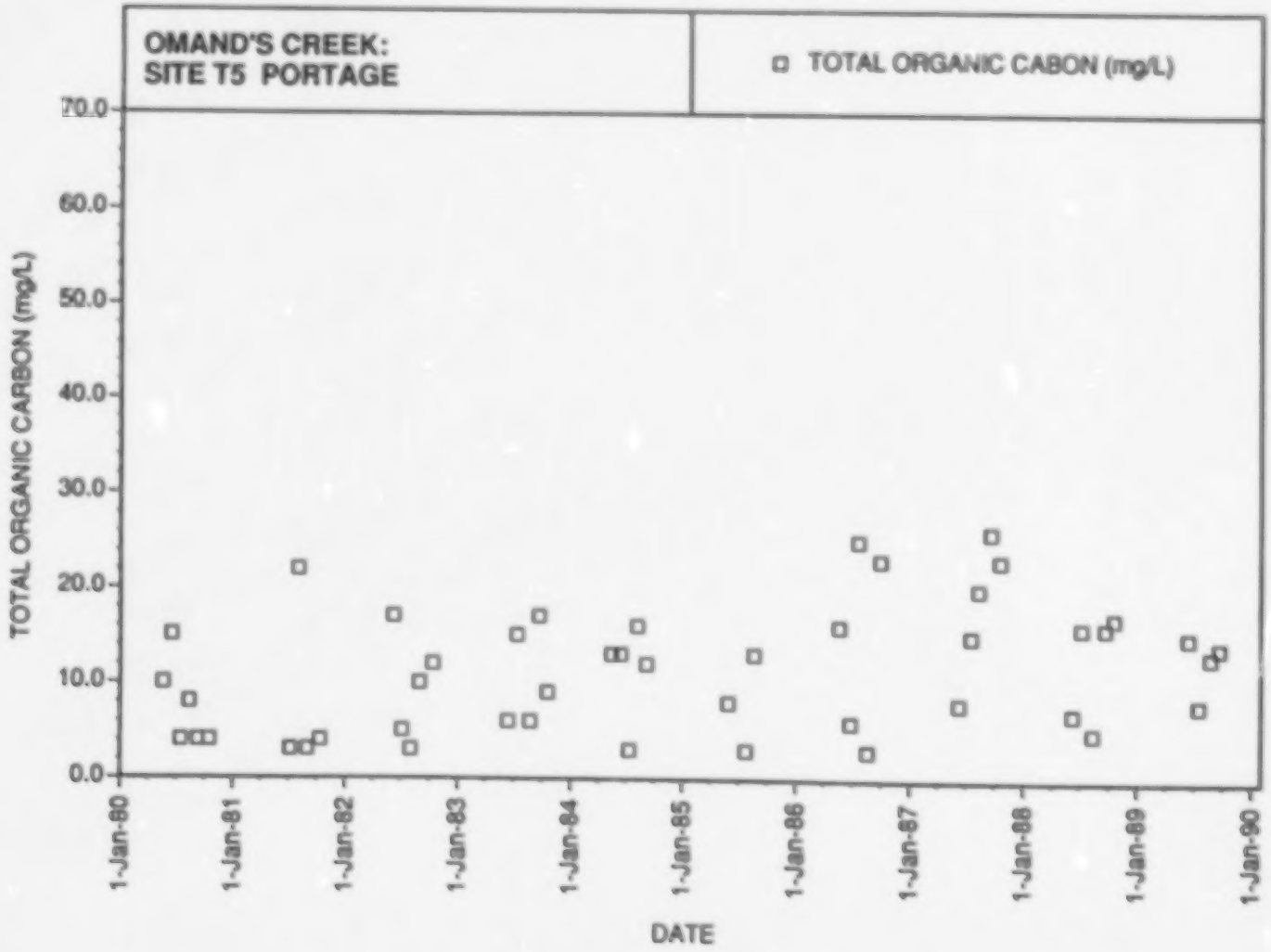


FIGURE A229: Total organic carbon concentrations in the La Salle River, at site T6 at Highway #75.

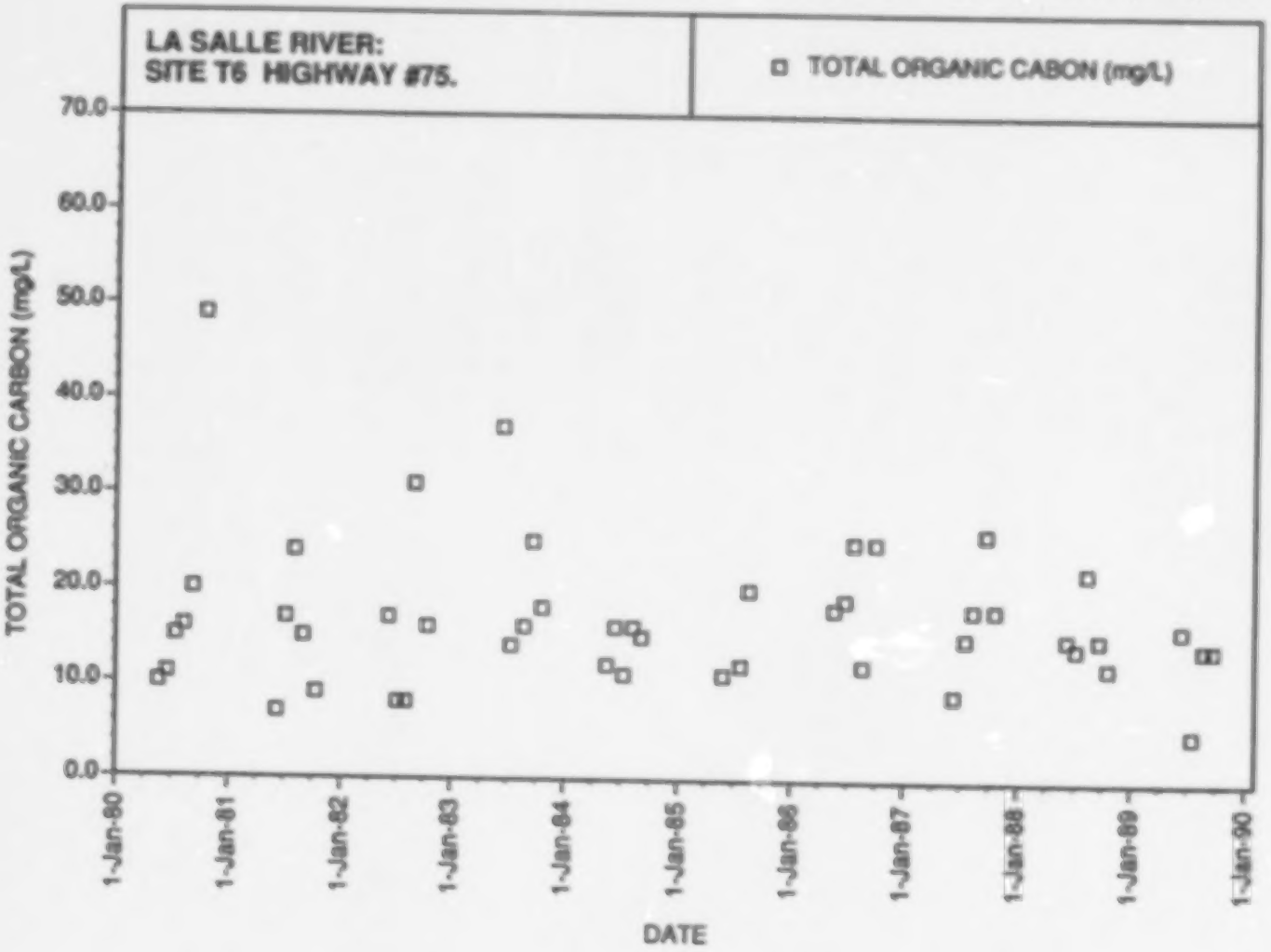


FIGURE A230: Total organic carbon concentrations in Bunn's Creek, at site T7 at Henderson Highway.

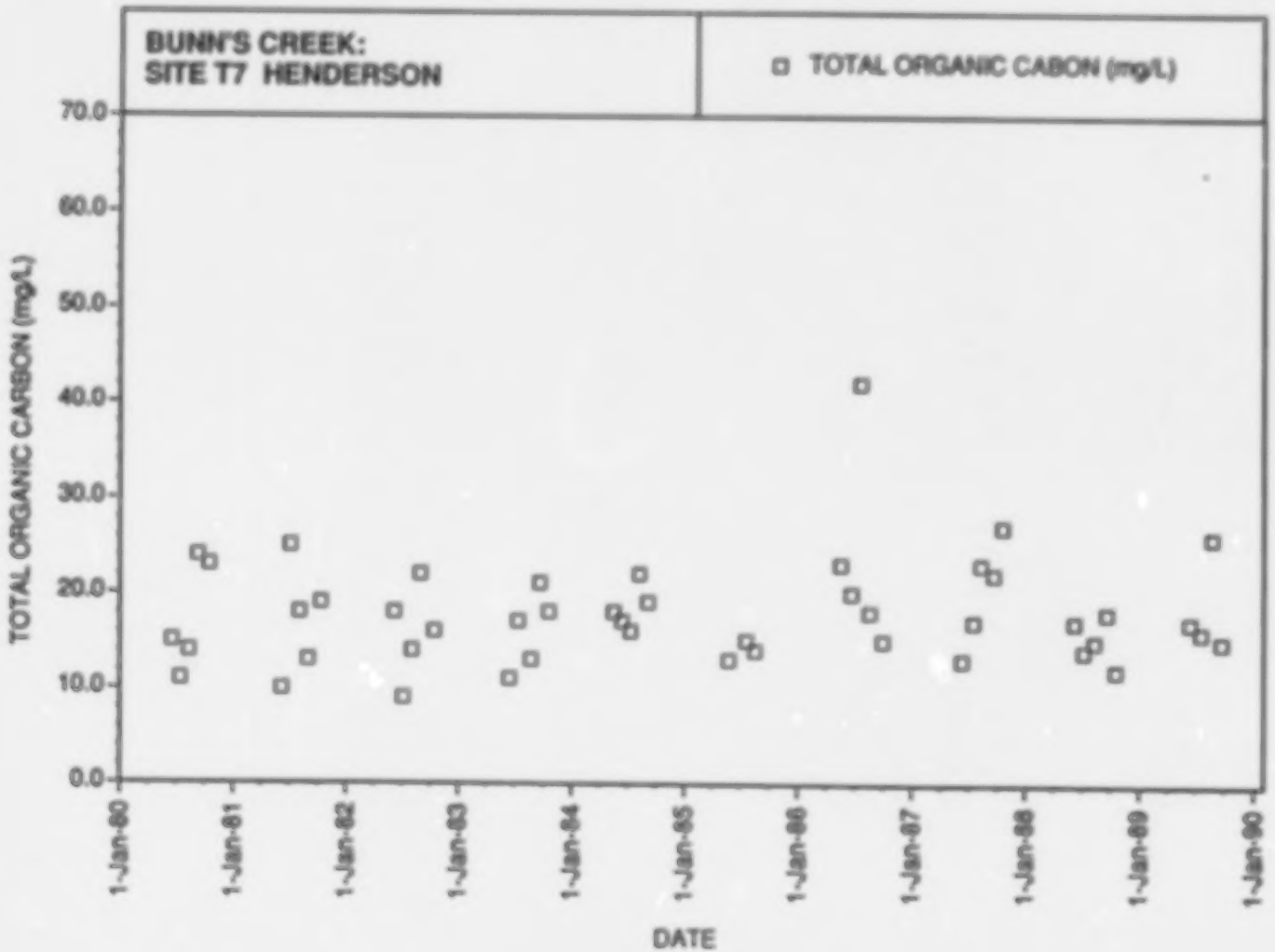


TABLE A114: Summary statistics for the total organic carbon data in the tributaries.

PARAMETER: TOTAL ORGANIC CARBON
MSWQO CLASSIFICATION: NOT APPLICABLE
OBJECTIVE: NONE

MAY-OCTOBER:1980-1989 DATA

SITE	MEAN	MIN	MAX	STDEV	N	NO. OF EXCEEDENCES	% EXCEEDENCE	MEAN OF EXCEEDENCE
T1-SEINE RIVER -HWY #59	21.0	6.0	53.0	9.0	48	N/A		
T2-SEINE RIVER -PROVENCHER	19.9	9.0	41.0	7.5	48	N/A		
T3-STURGEON CREEK -PERIMETER	13.1	2.0	35.0	8.4	48	N/A		
T4-STURGEON CREEK -PORTAGE	13.8	4.0	29.0	5.8	48	N/A		
T5-OMAND'S CREEK -PORTAGE	11.4	3.0	26.0	6.6	47	N/A		
T6-LA SALLE RIVER -HWY #75	16.8	5.0	49.0	7.8	48	N/A		
T7-BURNS CREEK -HENDERSON	17.7	9.0	42.0	5.6	48	N/A		

N/A = Not Applicable

TABLE A115: Trend analysis results for the total organic carbon data in the tributaries.

MAY-OCTOBER:1978-1989 DATA					
SAMPLING LOCATION	R2	P		TREND	N
T1-SEINE RIVER - HWY #59	0.13	0.007	**	INCREASING	58
T2-SEINE RIVER - PROVENCHER	0.10	0.014	*	INCREASING	58
T3-STURGEON CREEK - PERIMETER	0.03	0.166	N/S	INCREASING	58
T4-STURGEON CREEK - PORTAGE	0.03	0.190	N/S	INCREASING	58
T5-OMAND'S CREEK - PORTAGE	0.03	0.243	N/S	INCREASING	57
T6-LA SALLE RIVER - HWY #75	0.02	0.308	N/S	DECREASING	58
T7-BUNNS CREEK - HENDERSON	0.01	0.440	N/S	DECREASING	58

* indicates significance level at P<0.05
** indicates significance level of P<0.01
N/S indicates no significant trend (P>0.05)
N refers to the sample size